SCHOMANDL K G MUNICH

SERVICE FREQUENCY METER TYPE FD 1

and

CONVERTER UNIT TYPE FDM 1

Description and Service Instructions

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OFFICER
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Technical Description

and

Service Instructions

for the

SERVICE FREQUENCY METER FD 1

30 to 900 Mc/s

with

CONVERTER UNIT FDM 1

1 kc/s to 30 Mc/s

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Part II. Converter Unit type FDM 1

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AA.) How to use this manual

The manual on hand contains all the interesting facts about the Service Frequency Meter type FD 1 and the Converter Unit type FDM 1. Subsequent to the operating instructions, the electrical design is explained in Section B, "Mode of operation."

Chapter 2 of Section B, "Description of the individual stages," contains separate descriptions of the individual component units or stages of the equipment. Four circuit diagrams accompany the descriptions of each of the stages: a block diagram, an a-c voltage diagram, a d-c voltage diagram, and a wiring diagram.

When repairs have to be made, it is not necessary to read through the descriptions of all the stages, but it will suffice to study only the stage or stages involved in the failure. Section C, "Servicing instructions," at the end of this manual, is intended to facilitate determining which stage or lead is faulty.

With the help of that section and by means of the indications of the front panel elements it will be possible, after determining the appropriate key number, to locate the source of the fault by eliminating all the other stages or leads.

Naturally, it has not been possible to include all potential sources of trouble in this section, but care has been taken to cover as many as possible and to select the more probable ones.

If access has to be gained to the interior of the equipment in order to cope with the trouble, read instructions on how to take the equipment apart, given in Section D.

Part II of the manual describes the Converter Unit FDM 1. This supplement extends the frequency range of the Model FD 1 down to 1 kc/s, and the two instruments can be used together without any changes being necessary. The FDM 1 is simply fastened to the bottom of the FD 1 and plugged in, enabling the Model FD 1 to be used as a frequency meter and generator over the entire range of 1 kc/s to 90 Mc/s, with a reading accuracy of $\pm$ 50c/s or better.

BB.) Technical Data

a) Measuring range:

	FD 1	FD 1 + FDM 1
Range of variation of the fundamental frequency	30 to 92 Mc/s	0 to 92 Mc/s
Frequency range as a generator (with harmonics)	30 to 920 Mc/s	0 to 920 Mc/s
Measuring range as a frequency meter	1.5 to 920 Mc/s	1 kc/s to 920 Mc/s

b) Measuring accuracy when using fine tuning dial:

In the fundamental range	30 to 92 Mc/s	0 to 92 Mc/s
Maximum possible reading error and long-term stability of fine tuning dial	± 50 c/s	± 50 c/s
Resettability of fine tuning dial	± 20 c/s	± 20 c/s

c) Dial reading:

The frequency is read on three dials calibrated directly in frequency.

Dial	Calibration	Effect of dial inaccuracies on output
Mc/dial 10 kc/s dial	in steps of 1 Mc/s in steps of 10 kc/s	In the synchronised state, dial inaccuracies do not affect output.
fine tuning dial	in steps of 100 c/s	Dial inaccuracies affect output frequency in same order. Zero point can be readjusted.

d) Standard frequency:

The reference standard is obtained from a built-in 100 kc/s quartz crystal mounted in a thermostatically controlled oven. (Oven temperature 50° C or 60° C.)

Accuracy after switching on: . . . . . approx. 3×10^{-5}
Accuracy after 20 minutes: . . . . . approx. 2×10^{-6}
Accuracy after 30 minutes, over 24 hours: . . . . . approx. 1×10^{-7}

Stability over 6 months: . . . . . approx. 1×10^{-6}

e) Output voltage as a generator:

	FD 1	FD 1 + FDM 1
Output	coaxial socket	coaxial socket
Internal impedance	56 Ω ± 20%	approx. 3 kΩ
Voltages of fundamental frequencies	30 to 92 Mc/s: 10 mV	1 kc/s to 1 Mc/s: 200 mV 1 Mc/s to 10 Mc/s: 100 mV 10 Mc/s to 30 Mc/s: 30 mV
Voltages of harmonics		
2nd harmonic	60 to 184 Mc/s: 5 mV	
5th harmonic	150 to 460 Mc/s: 2 mV	
10th harmonic	300 to 920 Mc/s: 1 mV	
Level of non-harmonic spurious frequencies	approx. —70 db	

f) Input voltage as a frequency meter:

	FD 1	FD 1 + FDM 1
Input	coaxial socket	coaxial socket
Internal impedance	56 Ω ± 20%	approx. 100 kΩ
Sensitivity in the fundamental range	30 to 92 Mc/s: 2 mV	1 kc/s to 30 Mc/s: 5 mV
Sensitivity for harmonics		
2nd harmonic	60 to 184 Mc/s: 4 mV	
5th harmonic	150 to 460 Mc/s: 10 mV	
10th harmonic	300 to 920 Mc/s: 20 mV	

All voltages given above are approximate values!

Difference frequency indication: a) by headphones
b) (slow beats) by magic eye

g) Power supply:

Mains voltage . . . . . adjustable 110 V, 117 V, 127 V, 220 V, 235 V (40 to 60 c/s)

Power consumption . . . . . FD 1: 90 VA
FD 1 + FDM 1: 110 VA

h) Tube complement:

	FD 1	FDM 1
Tubes	14x EF 80 (6BX 6) 2x ECH 81 (6AJ 8) 1x E 80 CC (6085) 1x EAA 91 (6AL 5) 1x EM 85	2x EF 80 (6BX 6) 1x ECC 81 (12AT 7)
Stabiliser	1x 150 C 2 (O A 2)	1x 90 C 1
Signal Lamp	1x 18 V/0.1 A	1x 220 V E 10
Fuses	2x 1.5 A DIN 41571	1x 0.5 A DIN 41571

i) Dimensions, weight:

	FD 1	FD 1 + FDM 1
Width	250 mm (10")	250 mm (10")
Depth	270 mm (11")	270 mm (11")
Height	480 mm (19")	550 mm (22")
Weight	approx. 20 kg (45 lbs)	approx. 23 kg (51 lbs)

Part I

Service Frequency Meter FD 1

A. Operating instructions

1. Short description

The Frequency Meter type FD 1 contains a variable oscillator producing any single discrete frequency over a range of 30 to 90 Mc/s. This measuring frequency is controlled by a 100 kc/s precision quartz crystal mounted in a vacuum and in an oven.

The measuring frequency is set up on three dials calibrated directly in frequency. The sum total of the three dial readings is the fundamental frequency.

The first dial covers the frequency band 30 to 90 Mc/s in three ranges and can be synchronised every 1 Mc/s with crystal accuracy.

The second dial covering these 1 Mc/s intervals is calibrated 0 to 1 Mc/s and can be synchronised with quartz-crystal accuracy every 20 kc/s.

The third dial covers these 20 kc/s intervals in continuous tuning and is calibrated 0 to 20 kc/s. Its reading accuracy is better than $\pm$ 50 c/s. The first and the second dials can be desynchronised simultaneously (functional switch in position „SEARCH," so that they can be varied continuously in order to determine the approximate location of an unknown frequency. In the synchronised and in the non-synchronised state, the Frequency Meter FD 1 produces only one single frequency with non-harmonic disturbances at — 70 db down. This low level of disturbances permits not only a further multiplication of the output frequency to ensure a good harmonic output, but also the unequivocal mixing of the output with harmonics of unknown frequencies located below 30 Mc/s. The output of the equipment contains a mixer stage with LF amplifier having sufficient output to drive a pair of headphones.

The comparison of an unknown frequency against the reference frequency is done by forming the zero beat, which is made audible by headphones and displayed by the magic eye. Unknown frequencies above 90 Mc/s are compared to harmonics of the measuring frequency, which are formed in the output mixer stage by distortion. When measuring unknown frequencies below 30 Mc/s, their harmonics are measured. In this case, the unknown frequency must be fed into the socket "$f_x < 30$ Mc/s" provided for this purpose, under comparatively high voltage (approx. 2 to 5 V across 500 ohms), so that its harmonics can be produced by distortion.

The fundamental frequency (30 to 90 Mc/s) and its harmonics are also available as an active output, so that alignments of VHF receivers and other passive equipment are made possible.

Frequencies that are available only with very low voltage (e.g. when measuring distant transmitters), can be measured in the known manner by using a receiver to which both the frequency to be measured and the measuring frequency are fed, the latter being amplitude-limited by an appropriate attenuator, so that the zero beat can be checked at the receiver output.

2. Putting into operation

a) Connect frequency meter to power mains by means of extension cable and coupler plug (power input on back of equipment).

b) The power switch (S 2) is put to "on" (⊙). (The red signal lamp designated "OVEN" must now be on, to show that the oven is being heated up.) After the magic eye has also become luminant, the equipment is ready for operation, but so far only with an accuracy of 5×10^{-5}. Since the crystal oven is a rapid-heating type, the accuracy guaranteed by the manufacturer, 1×10^{-6}, will be reached after a warming-up period of only 15 to 30 minutes. Interruptions of the power supply of not more than 5 minutes will not vary the crystal frequency by more than 1×10^{-7}.

c) A general test of the dial calibration as described below has to be carried out only when using the frequency meter for the first time or when faulty measurements are apparent.

1. Checking the 10 kc/s dial:

Set functional switch (S 3) to position "MEASURE." (See Fig. 8) When varying dial throughout its range, the instrument on the left side of the dial should show a deflection for each dial point.

However, when pressing the key (S 5) located beside the 10 kc/s dial and designated "TEST," the instrument should show a deflection only for dial point 30×10 kc/s, which has been marked by a red dot.

If a correction is necessary, readjust dial by means of the slotted screw (R 43) located below the 10 kc/s dial.

Note:

The dial is synchronised to any dial point by varying it beyond the desired synchronisation point until the pointer of the instrument (J 1) beside the dial follows the movement of the dial. Then „pull" pointer into the red region of the instrument scale. The latter is done only to provide an easy and quick means of checking if the dial is still synchronised.

2. Checking the Mc/s dial:

Put functional switch (S 3) to position "MEASURE." Leave 10 kc/s dial in position 30 × 10 kc/s (red dot). When varying the Mc/s dial throughout its range and, at the same time, pressing the key (S 6) located beside the Mc/s dial and designated "TEST," a synchronisation deflection will be displayed for all those dial points which have been marked by a red dot. The luminant sectors of the magic eye will close and the pointer of the instrument (J 2) to the left of the dial will follow the dial movement. The synchronisation point is correctly adjusted when the pointer of the instrument is on center zero.

The correcting knob located below the Mc/s dial (R 78) serves for the fine adjustment of the oscillator frequency.

Note:

Slight deviations of the dial calibration do not affect the output frequency or the measuring result, i.e. the dial mark does not have to be exactly on the red dot when the instrument pointer is on center zero, but the calibration has to be good enough to enable the operator to distinguish quite clearly between the different synchronisation points.

d) Zero point of the fine tuning dial:

Deviations of the calibration of this dial (0 to 20 kc/s) will fully affect the accuracy of the output frequency. The zero point of this dial can therefore be recalibrated by means of a standard frequency. It will not be necessary to make this check every time before conducting a measurement, but it should be done after the equipment is switched on again or when measurements of the highest possible accuracy have to be made. For this purpose, the key "ZERO TEST" (S 4) located to the left of the fine tuning dial will be pressed and the knob "ZERO RESET" will be turned until the pointer of instrument J 2 located to the left of the Mc/s dial is on center zero.

Note:

Do not confuse the "0" point of the fine tuning dial with the „10 kc/s" point, which is also designated "0", only that it has been distinguished by the addition "+ 10 kc/s," in small letters.

After operations a) to d) have been completed, measurements can take place. The procedure is explained by way of an example in the following chapter.

3. Measurement of an unknown frequency fx

a) Connect headphones to socket "fx—fm" (Bu 9).

b) If the unknown frequency fx is above 30 Mc/s, it is connected to socket "OUTPUT fm/INPUT fx" (Bu 3), if it is below 30 Mc/s, to socket "INPUT fx < 30 Mc/s" (Bu 2), (when not using the Converter Unit FDM 1).

Voltages required:

I) fx ≧ 30 Mc/s: 5 mV to 100 mV across 60 ohms.

II) fx < 30 Mc/s: 500 mV to 2.5 V across 500 ohms, for measurements up to the 10th harmonic of the unknown frequency; 2.5 V to 5 V across 500 ohms, for measurements up to the 20th harmonic of the unknown frequency. Frequencies fx < 30 Mc/s must be obtained via an output winding or must have a d-c by-pass.

c) Put functional switch (S 3) to position "SEARCH."

d) Set 10 kc/s dial and fine tuning dial to "0". Check zero point of fine tuning dial (See 2. d) above).

e) Vary Mc/s dial slowly throughout its range until a beat tone becomes audible in the headphones. Leave dial so that beat remains audible.

f) Vary 10 kc/s dial slowly until magic eye shows a maximum luminant angle. (During this process, the pointer of the upper meter [J 2] will pass through center zero after coming from either margin. The beat remains audible.)

g) Set functional switch (S 3) to position "MEASURE."

h) Synchronise 10 kc/s dial to next lower calibration point. (Beat may become inaudible.)

i) The magic eye must now show a maximum luminant angle to show that the Mc/s dial has been synchronised. If, after switching S 3 from "SEARCH" to "MEASURE," the magic eye should not show a maximum deflection, which means that the Mc/s dial is no longer synchronised, it may be synchronised again by carefully turning the Mc/s dial in both directions. However, this will rarely happen.

k) Vary fine tuning dial until beat becomes audible again. Adjust to zero beat.

l) The pointer of the instrument (J 2) to the left of the Mc/s dial must be exactly on center zero; if it is not, it must be brought there by carefully turning the Mc/s dial or the Mc/s correction knob. (The magic eye must still display a maximum deflection.)

m) Put functional switch (S 3) to position "BEAT IND." and adjust beat displayed by magic eye to zero beat by means of fine tuning dial.

n) Read dials:

1st example:

Mc/s dial between 39 and 40	jot down:	**39**
10 kc/s dial on 64 (on this dial, numbers are read top to bottom: $\begin{matrix}6\\4\end{matrix}$)	jot down:	**64**
fine tuning dial on 4.6	jot down:	**4.6**
	measured frequency fx =	**39644.6 kc/s**

2nd example:

Mc/s dial between 39 and 40	jot down:	**39**
10 kc/s dial on 64	jot down:	**64**
fine tuning dial on 4.6 with index "+ 10 kc/s" written below:		
	jot down:	**4.6**
	add:	**10**
	measured frequency fx =	**39654.6 kc/s**

Note:

The indication of the frequency on the Mc/s dial is only an approximate one. That means, when the Mc/s dial is for instance on calibration point 39, and the 10 kc/s dial is on 95 × 10 kc/s, the output frequency will be 38.95 Mc/s, regardless whether the mark of the Mc/s dial is 2 mm to the left or to the right of the dial point, (which may happen due to a possible deviation of the dial calibration, but is without any influence on the output frequency).

4. Setting a desired frequency

Example: 39654.6 kc/s

a) Set fine tuning dial to "0" and check zero point.

b) Set fine tuning dial to "4.6 kc/s + 10 kc/s."

c) Set functional switch (S 3) to "MEASURE."

d) Synchronise 10 kc/s dial to "64 × 10 kc/s."

	644.6 kc/s
+	10 kc/s
=	654.6 kc/s

e) Turn Mc/s dial slowly from 39 to 40 Mc/s, the dial will become synchronisable when it is approximately in the middle between 39 and 40 Mc/s (corresponding to 654.6 kc/s). The luminant sector of the magic eye will suddenly increase and the pointer of the upper instrument (J 2) will follow the dial movement. The pointer of this instrument (J 2) must now be pulled to center zero by carefully turning the Mc/s dial knob or the Mc/s correction knob.

Measurements of $fx > 90$ Mc/s and $fx < 30$ Mc/s.

When measuring by means of harmonics, where $fx > 90$ Mc/s but otherwise entirely unknown, the following formulae will be helpful in determining the ordinal number of the employed harmonic:

$$n_1 = \frac{f_2}{f_2 - f_1} \; ; \; fx = n_1 \cdot f_1.$$

When measuring harmonics of $fx < 30$ Mc/s, these formulae are applicable:

$$n_1 = \frac{f_1}{f_2 - f_1} \; ; \; fx = \frac{f_1}{n_1},$$

f_1 and f_2 being the frequency values of two successive beat tones.

B. Mode of operation

1. Principles of operation

a) Main oscillator, mixer-distorter, and acoustic indication (see Fig. 7)

The main oscillator supplies the frequency required for active and passive measurements, which is generated in a tube excited in a capacitive ECO circuit (V 17). The frequency band of 30 to 90 Mc/s is broken down into three ranges: 30 to 43 Mc/s, 42 to 61 Mc/s, and 60 to 90 Mc/s. The voltage of the frequency tuned is obtained via a coupling element from the plate and conducted to a distorter (Gr 14) which forms the harmonics, (see Fig. 1).

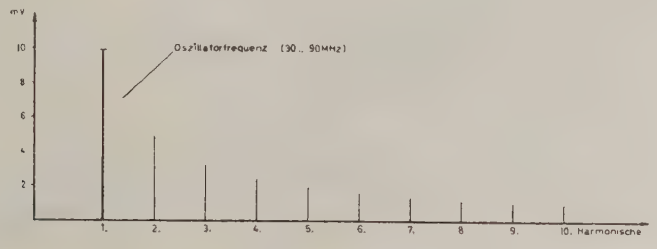


Fig. 1: Voltages of the harmonic output.)*

From there, the momentaneous frequency and its harmonics are conducted to the output socket (Bu 3), where they are available for active measurements. At the same time, this harmonic generator operates as a mixer stage, when passive measurements are to be performed.

The resulting difference frequency is supplied to an LF amplifier and can be fed into headphones and the zero beat can be formed. When switching the functional switch (S 3) to position "BEAT IND.," very slow beats can also be observed by means of the magic eye.

For measurements in the range 1.5 Mc/s to 30 Mc/s, the frequency to be measured has to be distorted in order to obtain its harmonics. For this purpose, a second input socket (Bu 2) has been provided which is connected to socket Bu 3 via a distorter diode (Gr 13).

In order to obtain an adequate harmonic output by means of a Germanium diode, a minimum voltage of 1 V is required, so that for measurements below 30 Mc/s a voltage of at least 1 V is necessary. The higher the ordinal number of the harmonic of the frequency to be measured, the higher is the required voltage, (for instance: the 20th harmonic of a frequency in the vicinity of 1.5 Mc/s requires a voltage of approx. 5 V).

The arrangement described above constitutes the frequency meter and generator proper. All the other stages described below serve only the purpose of assuring a reading accuracy of ± 50 c/s of the output frequency of the main oscillator.

Synchronisation of the main oscillator in steps of 1 Mc/s.

In order to facilitate the understanding of this process, two assumptions will be made:

1. The vernier oscillator controlled by the 10 kc/s dial is assumed to render a frequency of 4.7 Mc/s (dial position "0 × 10 kc/s"); at the same time, the variable filter (Sp 14, Sp 15), the tuning of which is ganged to the 10 kc/s dial, is tuned to 5 Mc/s.
2. The fine tuning dial (variable discriminator) is assumed to be in position „0," which means that it does not produce an AFC voltage, when a frequency of 300 kc/s is supplied to it. (This will be explained later.)

The momentaneous frequency (30 to 90 Mc/s) of the main oscillator is supplied to the first mixer stage (V 15), where it is heterodyned with a standard frequency that differs from it by 5 Mc/s. This standard frequency is obtained from a 1 Mc/s standard frequency spectrum by means of a variable filter (Sp 23

)* For the terms used in the illustrations see Nomenclature at the end of this manual.

to Sp 28) with a tuning range of 25 to 85 Mc/s. This variable filter has a bandwidth of 1 Mc/s and is ganged to the tuning of the main oscillator at a frequency interval of 5 Mc/s. (For further explanations see page 17). Therefore, the two variable capacitors (C 95, C 97) of the two filter circuits and the variable capacitor of the oscillator (C 114) are mounted on the same axle (see Fig. 2).

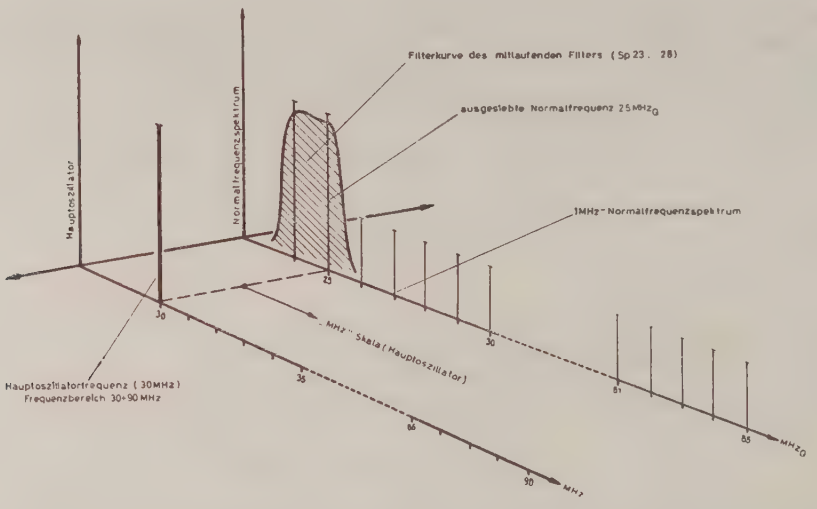


Fig. 2: Heterodyning of the frequency of the main oscillator with a standard frequency (at a 5 Mc/s interval).

The first mixer stage (V 15) is followed by a variable filter (Sp 14, Sp 15) covering a frequency range of 5 to 6 Mc/s, which is at present tuned to 5 Mc/s (see assumption 1!). Therefore, after each step of 1 Mc/s, a frequency of 5 Mc/s is applied to the 2nd mixer stage (V 11).

This 5 Mc/s frequency per 1 Mc/s step is heterodyned in the 2nd mixer stage (V 11) with the frequency of the vernier oscillator (frequency: 4.7 to 5.7 Mc/s), which is at present tuned to 4.7 Mc/s (see assumption 1!). The resulting difference frequency of 300 kc/s is selected in the following bandpass filter (Sp 16, Sp 17), which has a passband of 300 to 320 kc/s, and fed into a variable discriminator. This discriminator is at present tuned to position "0" (see assumption 2), so that the variable circuit (C 86, Sp 20) is in resonance with 300 kc/s. Therefore, the variable discriminator does not render a control voltage. It is obvious that the correct tuning of this variable circuit is essential for the accuracy of the output frequency. Therefore, it is possible to readjust the zero point of the fine tuning dial, by pressing the zero test key (S 4) and then adjusting the control voltage to zero by means of the knob "ZERO RESET," that is, the pointer of the instrument J 2 (to the left of the Mc/s dial) has to be brought to center zero. Here, an accuracy of ± 30 c/s can be attained, since 1 mm of the meter dial corresponds to a frequency deviation of 30 c/s.

A more detailed presentation of the operation of the variable discriminator is given in chapter c) Fine tuning stage.

The description of the circuitry used for the synchronisation of the main oscillator has been based on the assumption that the main oscillator is set to any Mc/s point of its dial with crystal accuracy. If it is detuned now in either direction, the converted frequency of 300 c/s at the variable discriminator will be varied, so that the phase relation between the voltage of the tuned circuit and that of the variable circuit changes, too.

A control voltage is therefore produced (to be seen at instrument J 2) which varies, through the reactance tube (V 16), the oscillator circuit of the main oscillator (V 17) and therefore its frequency, in the correct direction. In other words, when the frequency is varied, the AFC circuit counteracts that process and pulls the frequency back to the original value.

Within the AFC range, the control factor is 1 : 200, i.e. when the dial is varied by 10 kc/s off the Mc/s point, the frequency is changed by only 500 c/s = 1/200.

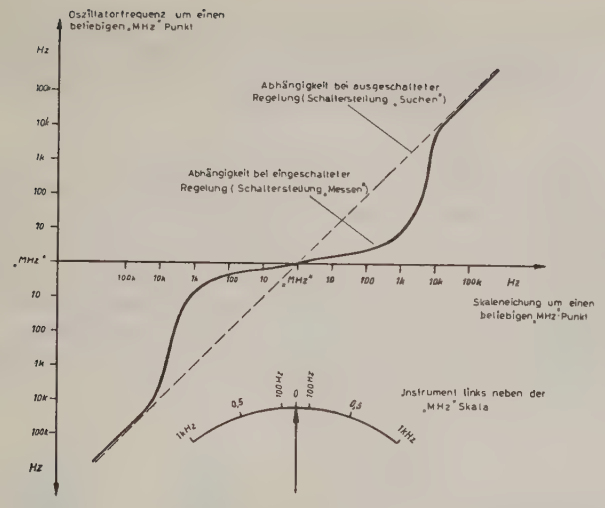


Fig. 3: AFC characteristic of a Mc/s synchronisation point of the main oscillator.

This control factor can easily be seen from the characteristic shown in Fig. 3. The situation depicted there repeats itself again and again on the Mc/s dial at intervals of 1 Mc/s. In addition, the instrument (J 2) to the left of the Mc/s dial is depicted schematically and has been given a coarse calibration in order to give an idea of the setting accuracy of the main oscillator. Since a meter may be set with an accuracy of 1 mm with certainty, the setting accuracy of the main oscillator is claimed to be ± 30 c/s in the synchronisation range.

The arrangement described above permits the setting of frequencies with crystal accuracy at intervals of 1 Mc/s over a range of 30 to 90 Mc/s. The setting is done within the synchronisation range of one Mc/s point by adjusting the dial in such a way that the pointer of the meter is on center zero. In the following chapter, the influence of the vernier oscillator on the frequency of the main oscillator is described.

Frequency adjustment in steps of 20 kc/s.

The vernier oscillator (V 11) can be synchronised every 20 kc/s in a fixed phase relation with the synchronising standard. That means, it renders a (secondary) standard frequency at intervals of 20 kc/s over a range of 4.7 to 5.7 Mc/s. (This synchronisation process is explained in chapter b), Vernier oscillator.)

As shown above, the vernier oscillator must furnish a frequency of 4.7 Mc/s in order to make a synchronisation of the Main oscillator possible on every Mc/s point. If this vernier oscillator is tuned to 4.72 Mc/s, a frequency of 320 kc/s is present at the variable discriminator (Sp 20) instead of 300 kc/s. Therefore, a control voltage is produced that shifts the main oscillator in the correct direction. (Indication on instrument J 2.) In spite of this, the dial of the main oscillator must also be varied, i.e. readjusted by 20 kc/s, in order that the pointer of the instrument returns to "0" (control voltage = 0). As a result, the frequency present at the variable discriminator is again 300 kc/s, so that no control voltage is produced.

This variation by 20 kc/s can be done over a total range of 1 Mc/s (up to 5.7 Mc/s). This explains why the variable filter (25 to 85 Mc/s) has to have a bandwidth of 1 Mc/s (see page 16). The main oscillator must be able to form a difference frequency of 5 to 6 Mc/s (variation by 1 Mc/s!) with any point of the standard frequency spectrum. Since however the variable capacitor of the main oscillator (30 to 90 Mc/s) is ganged to those of the filter tuning (25 to 85 Mc/s), which latter would otherwise rest on the 1 Mc/s synchronisation point sharp, the filter must have a bandwidth of 1 Mc/s.

The variable filter of 5 to 6 Mc/s is ganged to the tuning of the vernier oscillator (V 11") and selects the corresponding difference frequency. In the second mixer stage (V 11'), the second difference frequency of 300 kc/s is formed with the frequency of the vernier oscillator.

> Important: The frequency shown by the Mc/s dial is actually the frequency produced by the main oscillator. The 10 kc/s dial and the fine tuning dial serve only to increase the accuracy with which that frequency can be read.

d) Standard frequency supply

The claimed measuring accuracy of the FD 1 is made possible by using a crystal-controlled oscillator for a frequency standard. It consists of a 100 kc/s quartz crystal placed in a thermostatically controlled rapid-heating oven. Its stability is better than 1×10^{-6} over long periods of time (several months).

To be properly used, the 100 kc/s standard frequency supplied by this crystal oscillator must be converted into various secondary standards.

1. The 20 kc/s_Q standard is obtained by means of a 5:1 divider from the 100 kc/s standard.

2. The required 1 Mc/s_Q standard frequency spectrum ranging from 25 Mc/s to 85 Mc/s is produced by stepwise multiplication (100 $kc/s_Q \rightarrow$ 200 $kc/s_Q \rightarrow$ 1 $Mc/s_Q \rightarrow$ 5 $Mc/s_Q \rightarrow$ 20 Mc/s_Q). Here, the circuits used have such a large bandwidth that the 1 Mc/s_Q frequency coming into existence in the form of sidebands is not eliminated. At the output of this multiplier chain is a distorter (Gr 12) that converts the resulting frequency mixture into the required spectrum.

3. For the synchronisation of the vernier oscillator a standard frequency of 5 Mc/s_Q is required. It is coupled out from the 5 Mc/s multiplier circuit (Sp 8) via an additional filter (Sp 9, C 36).

e) Test keys

Three push buttons have been provided on the front panel of the FD 1 for servicing purposes and for testing the calibration of the dials. The individual purpose and application of these keys will now be explained:

1. Test key S 6, located below the instrument (J 2) of the main oscillator:

   This key is used for testing the dial calibration of the main oscillator. Normally, the calibration can be tested by means of the 1 Mc/s synchronisation points. It may happen, however, that the oscillator frequency does not correspond with the dial calibration any longer, due to some influence or other, so that the synchronisation actually occurs between two 1 Mc/s dial points and it cannot be distinguished any longer which synchronisation point of the oscillator corresponds to which 1 Mc/s dial point.

   When now the test key (S 6) is pressed, the harmonic generator is switched in such a way that a 5 Mc/s spectrum is generated instead of the original 1 Mc/s spectrum, to the effect that the oscillator is synchronised only every 5th 1 Mc/s point. The corresponding synchronisation points on the dial have been marked by red dots.

   Here, it will be noted that these calibration marks are located about 300 kc/s to the left of the Mc/s synchronisation point proper. The reason for this is explained below:

   Since a pure 5 Mc/s spectrum is required, the 5 Mc/s_Q standard frequency cannot be used, because it has some 1 Mc/s_Q sidebands. In order to avoid the use of additional filter circuitry, the 5 Mc/s frequency of the vernier oscillator is used to produce the 5 Mc/s spectrum by feeding the oscillator frequency into the distorter (V 6).

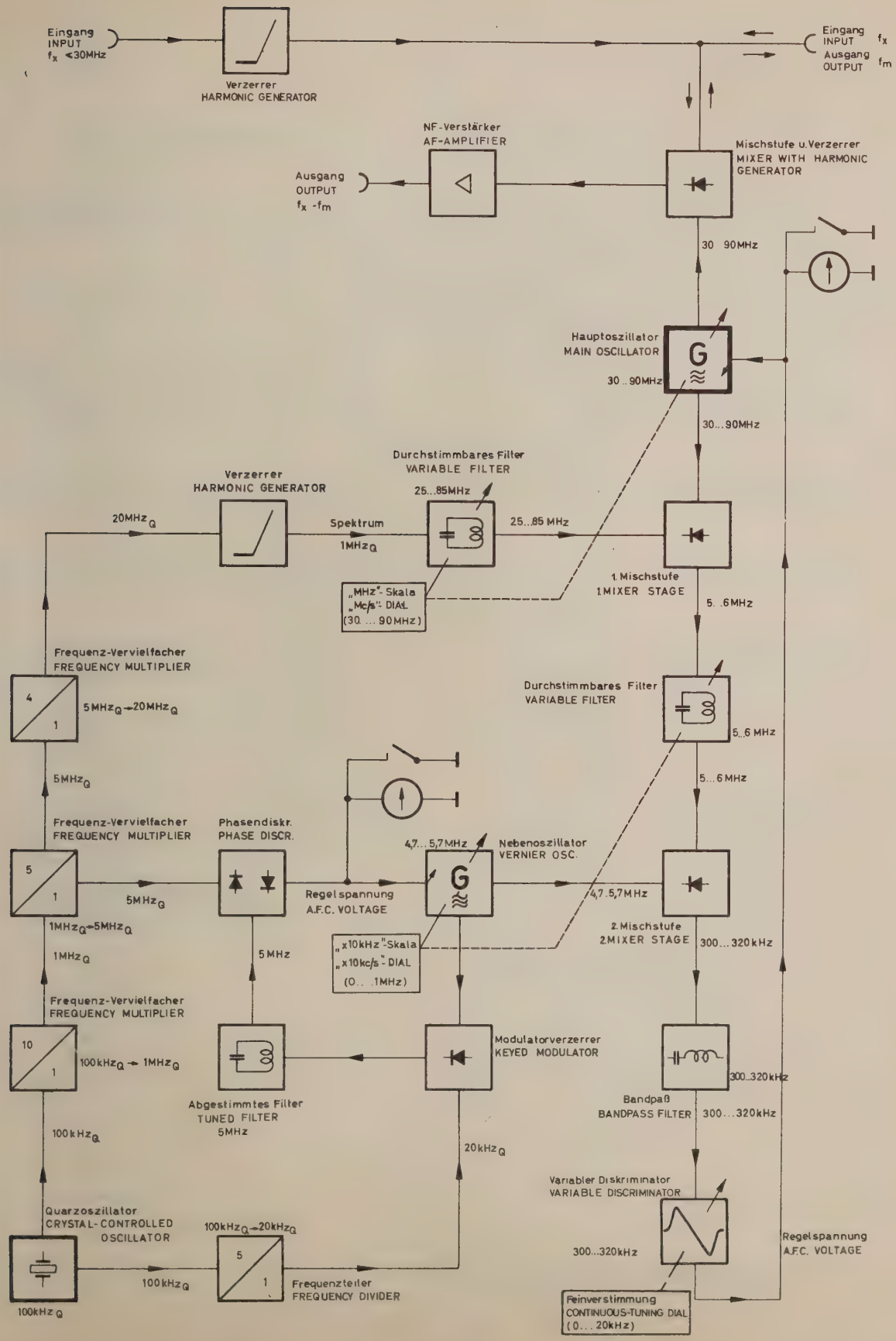
   However, the vernier oscillator produces a frequency of 5 Mc/s only when its dial is on position "30 × 10 kc/s". Therefore, that dial has to be set to position "30 × 10 kc/s" (marked by a red dot, too), before testing the dial calibration of the main oscillator. And that explains why the red marks on the main oscillator dial are about 300 kc/s off the 1 Mc/s dial points.

2. Test key S 5, located below the instrument (J 1) of the vernier oscillator:

   This key serves for testing the calibration of the dial of the vernier oscillator. Here, too, it is normally possible to check the calibration by means of the synchronisation points spaced 20 kc/s_Q apart. However, it may happen here, too, that it cannot be distinguished any longer which dial point corresponds to which synchronisation point of the oscillator.

   The key S 5 interrupts the plate voltage supply for the 5:1 divider (100 kc/s → 20 kc/s). When this 20 kc/s_Q standard is eliminated, only one frequency can pass through the 5 Mc/s filter (Sp 11) located in the synchronisation circuitry of the vernier oscillator, namely the 5 Mc/s frequency that is produced in dial position "30 × 10 kc/s" (see page 18). Therefore, a synchronisation deflection will appear on the instrument (J 1) located to the left of the vernier oscillator dial only for this dial position (marked by red dot!). The dial can then be corrected by means of the regulator R 43 located below the dial of the vernier oscillator.

Bild 7 Service Frequenzmesser FD1 (Blockschaltbild)
FIG 7 SERVICE FREQUENCYMETER FD1 (BLOCK DIAGRAM)



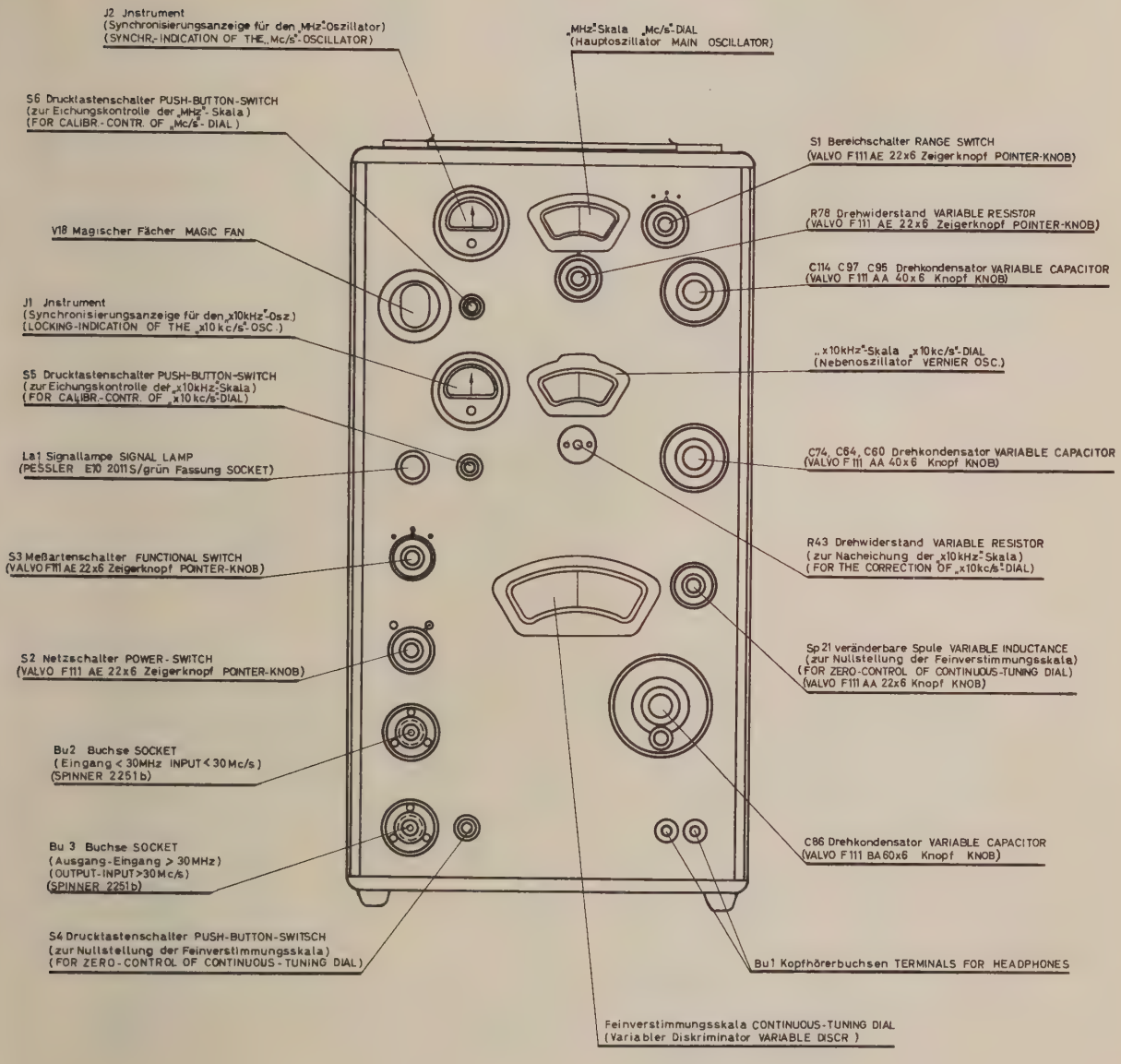

J2 Instrument
(Synchronisierungsanzeige für den „MHz"-Oszillator)
(SYNCHR.-INDICATION OF THE „Mc/s"-OSCILLATOR)
„MHz"-Skala „Mc/s"-DIAL
(Hauptoszillator MAIN OSCILLATOR)
S6 Drucktastenschalter PUSH-BUTTON-SWITCH
(zur Eichungskontrolle der „MHz"-Skala)
(FOR CALIBR.-CONTR. OF „Mc/s"-DIAL)
S1 Bereichschalter RANGE SWITCH
(VALVO F111 AE 22x6 Zeigerknopf POINTER-KNOB)
R78 Drehwiderstand VARIABLE RESISTOR
(VALVO F111 AE 22x6 Zeigerknopf POINTER-KNOB)
V18 Magischer Fächer MAGIC FAN
C114 C97 C95 Drehkondensator VARIABLE CAPACITOR
(VALVO F111 AA 40x6 Knopf KNOB)
J1 Instrument
(Synchronisierungsanzeige für den „x10kHz"-Osz.)
(LOCKING-INDICATION OF THE „x10kc/s"-OSC.)
„x10kHz"-Skala „x10kc/s"-DIAL
(Nebenoszillator VERNIER OSC.)
S5 Drucktastenschalter PUSH-BUTTON-SWITCH
(zur Eichungskontrolle der „x10kHz"-Skala)
(FOR CALIBR.-CONTR. OF „x10kc/s"-DIAL)
La1 Signallampe SIGNAL LAMP
(PEßLER E10 2011S/grün Fassung SOCKET)
C74, C64, C60 Drehkondensator VARIABLE CAPACITOR
(VALVO F111 AA 40x6 Knopf KNOB)
R43 Drehwiderstand VARIABLE RESISTOR
(zur Nacheichung der „x10kHz"-Skala)
(FOR THE CORRECTION OF „x10kc/s"-DIAL)
S3 Meßartenschalter FUNCTIONAL SWITCH
(VALVO F111 AE 22x6 Zeigerknopf POINTER-KNOB)
Sp 21 veränderbare Spule VARIABLE INDUCTANCE
(zur Nullstellung der Feinverstimmungsskala)
(FOR ZERO-CONTROL OF CONTINUOUS-TUNING DIAL)
(VALVO F111 AA 22x6 Knopf KNOB)
S2 Netzschalter POWER-SWITCH
(VALVO F111 AE 22x6 Zeigerknopf POINTER-KNOB)
Bu2 Buchse SOCKET
(Eingang < 30MHz INPUT < 30 Mc/s)
(SPINNER 2251b)
C86 Drehkondensator VARIABLE CAPACITOR
(VALVO F111 BA 60x6 Knopf KNOB)
Bu 3 Buchse SOCKET
(Ausgang-Eingang > 30MHz)
(OUTPUT-INPUT > 30 Mc/s)
(SPINNER 2251b)
S4 Drucktastenschalter PUSH-BUTTON-SWITSCH
(zur Nullstellung der Feinverstimmungsskala)
(FOR ZERO-CONTROL OF CONTINUOUS-TUNING DIAL)
Bu1 Kopfhörerbuchsen TERMINALS FOR HEADPHONES
Feinverstimmungsskala CONTINUOUS-TUNING DIAL
(Variabler Diskriminator VARIABLE DISCR.)

Bild 8 Service Frequenzmesser FD1 (Frontplattenansicht)
FIG. 8 SERVICE FREQUENCYMETER FD1 (FRONT PANEL VIEW)

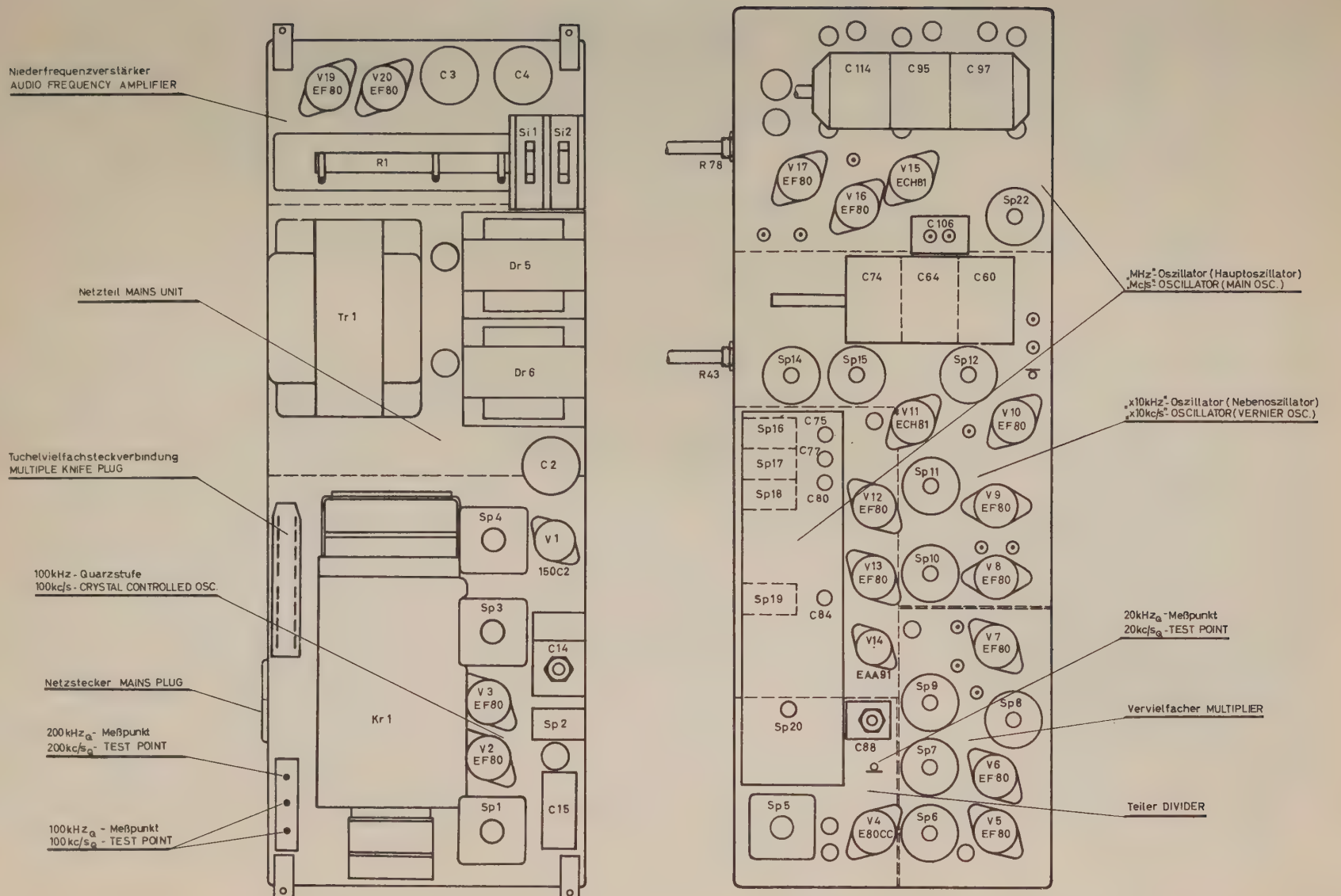


Bild 9 Ansicht der FD1 CHASSIS
FIG. 9 VIEW OF THE FD1 CHASSIS

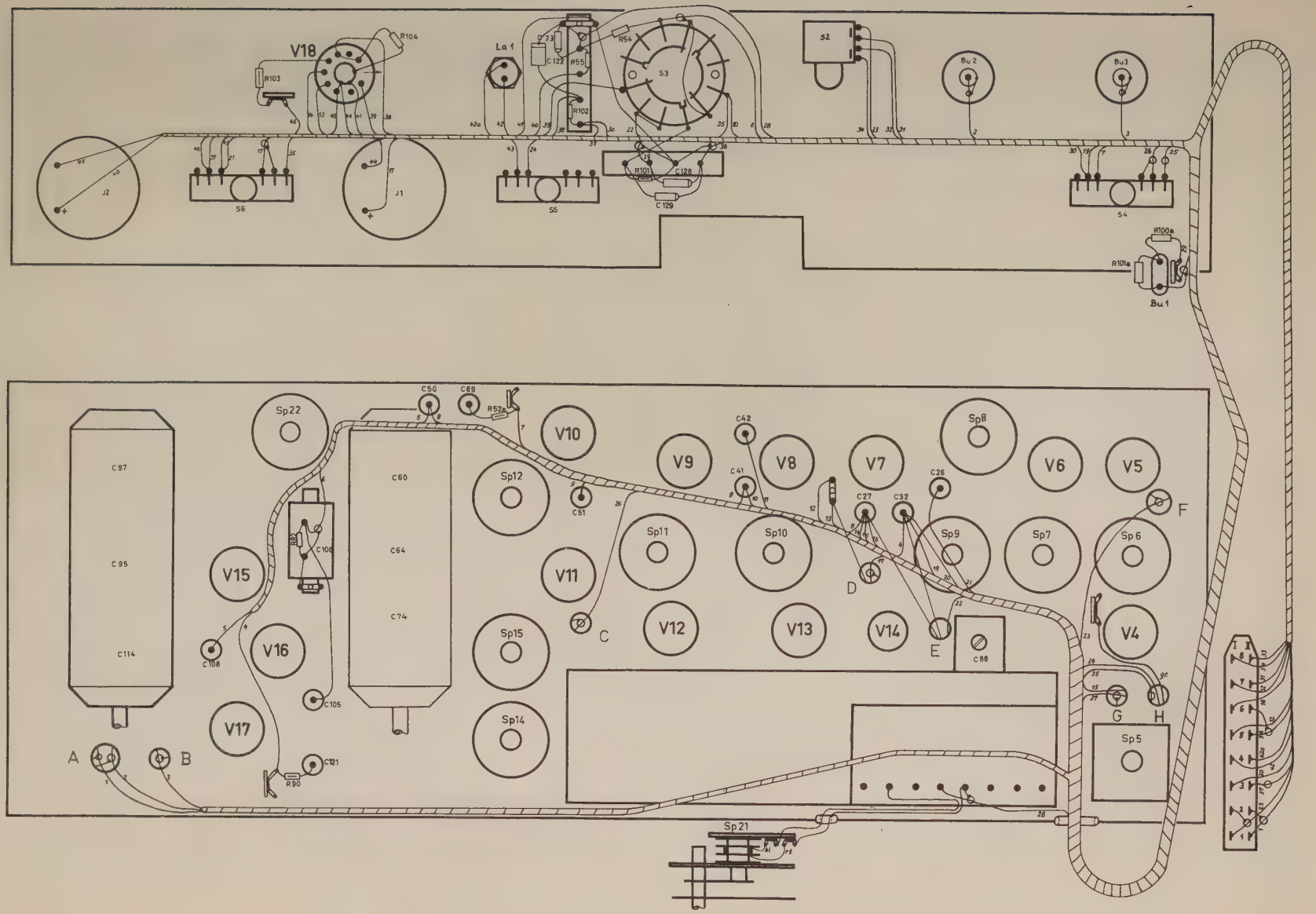


Bild 10 Montageplatte und Verkabelung für FD1
FIG. 10 WIRING BETWEEN CHASSIS AND FRONT PANEL ELEMENTS

3. Zero test key S 4, located beside the fine tuning dial:

As has been mentioned earlier, the accuracy of the output frequency depends on the phase angle of the voltage of the tuned circuit Sp 19 with regard to that of the variable circuit Sp 20. In position "0," at a frequency of 300 kc/s, the phase angle should be 90°. (The AFC voltage for the main oscillator is now zero.)

This condition should be checked now and then and after switching the equipment on. This is done by means of the key "ZERO TEST." When this key is pressed, a standard frequency of 300 kc/s_Q is supplied to the discriminator circuit. Now, the variable circuit may be readjusted in such a manner by means of the zero regulator (Sp 21) that the phase angle is exactly 90°. This can be checked on the instrument (J 2) located beside the dial of the main oscillator, the pointer of which must be on center zero.

2. Description of the individual stages

a) 100 kc/s crystal-controlled oscillator

In order to attain a measuring accuracy of 1×10^{-6} with the frequency meter FD 1 as claimed by the manufacturer, a reference standard of exceedingly high accuracy has to be available. This standard is produced by the 100 kc/s crystal oscillator, which contains a replacable quartz crystal mounted in an oven, the heating of which is controlled by a thermostat, so that the temperature of the space surrounding the crystal is kept constant and its frequency is stabilised to a high degree.

The 100 kc/s_Q standard frequency of high stability, which is used for a number of purposes within the equipment, is furthermore converted into a 200 kc/s_Q standard by doubling.

The quartz crystal and its oven form one unit, manufactured by Siemens & Halske. If they should happen to be defective, they can easily be replaced by pulling the unit from its support and plugging a new one in.

The oven is heated by a 20 volt d-c voltage and has a power consumption of approx. 10 VA. The temperature is kept constant at either 50° C or 60° C. When the heating device is in operation, this is indicated by a red signal lamp (La 1) located on the front panel.

The 100 kc/s crystal oscillator will now be described by means of the block diagram (Fig. 11) and the d-c voltage diagram (Fig. 12).

The oscillator circuit (V 2, Sp 1) with the quartz crystal operates in the following manner:

The resonant circuit (Sp 1, C 6) and tube V 2 form a 100 kc/s oscillator. In the cathode circuit of V 2, a coil has been inserted that has such a high resistance that the circuit arrangement cannot oscillate at its proper frequency (Sp 1, C 6). If the 100 kc/s crystal is now connected in parellel to coil Sp 2, it will present a low resistance for oscillations at its resonant frequency so that Sp 2 is short-circuited. The stage oscillates therefore at the resonant frequency of the crystal.

If the crystal were to be replaced by a resistor whose resistance would correspond to the resistance of the crystal at its resonant frequency, (400 ohms), the stage would oscillate at its own proper frequency. The diode Gr 2 operates as an amplitude limiter keeping the amplitude so small that the crystal is strained only little. This measure also increases the frequency stability.

The crystal frequency is fed to the amplifier tube V 3 via a coupling capacitor C 8. A transformer (Sp 3) tuned to 100 kc/s is inserted in the plate circuit of V 3 and the 100 kc/s frequency is obtained from its secondary and fed into the divider via a multiple plug connection on the one hand, and into a doubler stage (Gr 3, Gr 4) on the other hand. The 200 kc/s doubled crystal frequency is obtained through a tapping from the tuned transformer (Sp 4, C 13) and fed to the multiplier via a multiple cable connection.

Some approximate voltage values are shown in the a-c voltage diagram, Fig. 12, which have to be measured with a tube voltmeter of small input capacitance.

The voltage values shown in the d-c voltage diagram, Fig. 13, are also only approximate values which may vary slightly with each equipment. These voltages must be measured with a d-c voltmeter with an internal impedance of 50 k-ohms per volt.

The plate voltages for tubes V 2 and V 3 are obtained from a stabiliser tube (V 1, type 150 C 2).

The enclosed wiring diagram (Fig. 14) serves to facilitate the locating of the individual circuit elements. If repairs have to be made on the 100 kc/s crystal oscillator, remove the hood of the equipment, unscrew the four fixing screws of the chassis of the power supply and remove the chassis. Then reinsert the multiple plug that has been pulled first. The wiring of the two chassis is now accessible while both units are serviceable.

Calibrating instructions:

Resonant circuit (Sp 1, C 6):

The oven with crystal is pulled from its support, coil Sp 2 is short-circuited by a 470 ohms resistor and the rectifier Gr 2 is disconnected at one terminal.

The core of coil Sp 1 is now adjusted in such a way that the oscillator stage oscillates at a frequency of 100 kc/s. The correct adjustment of the frequency should be ascertained by comparing it to a 100 kc/s external standard by means of an oscilloscope. The frequency to be measured can be obtained at the "100 kc/s_Q test point" (see wiring diagram Fig. 14). Here, the transformer circuit Sp 3, C 10, has to be tuned roughly to 100 kc/s.

The connection of the rectifier Gr 2 is then soldered back into place, the 470-ohms by-pass resistor is removed, and the oven is placed in its support again.

Now, a slowly turning Lissajous figure must be visible on the oscilloscope screen, which should be brought to standstill by means of the trimmer C 14 after a running-in period of the oven of one hour. If the range of variation of trimmer C 14 should not suffice, the capacitor C 15 may be exchanged.

Tuned transformer (Sp 3, C 10):

A voltmeter is connected to the "100 kc/s_Q test point" instead of the oscilloscope. Then adjust core of coil Sp 3 to maximum deflection.

Tuned transformer (Sp 4, C 13):

Connect voltmeter to "200 kc/s test point" and adjust core of coil Sp 4 to maximum deflection.

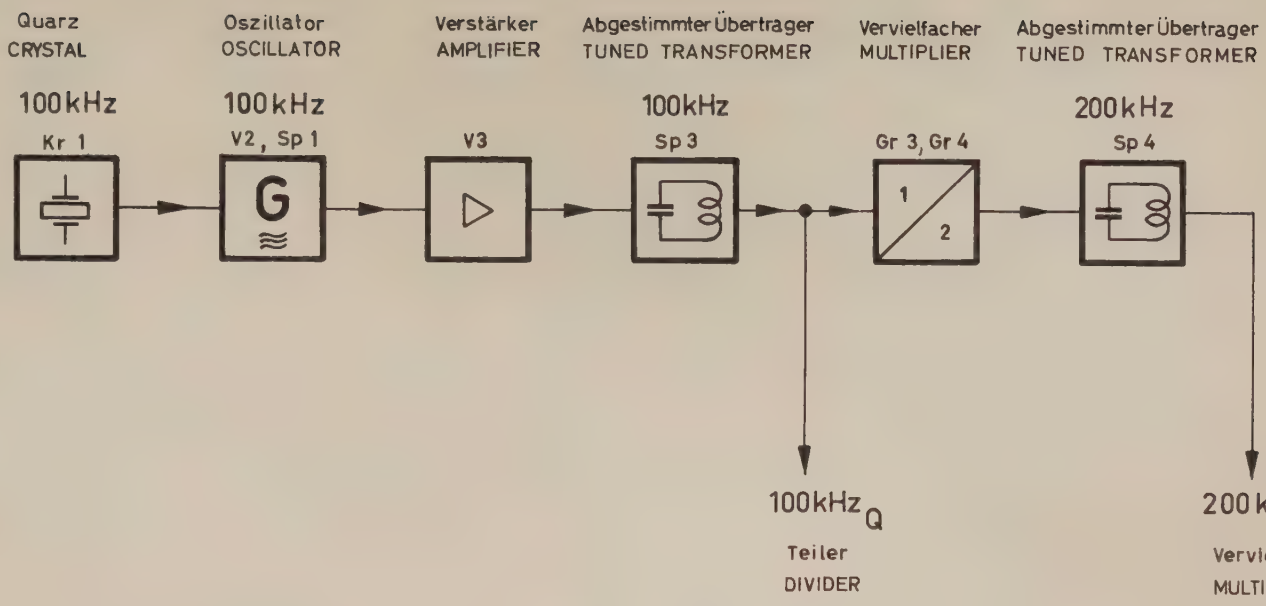


Bild 11 100kHz Quarzstufe (Blockschaltbild)
FIG. 11 100kc/s CRYSTAL CONTROLLED OSCILLATOR
(BLOCK DIAGRAM)

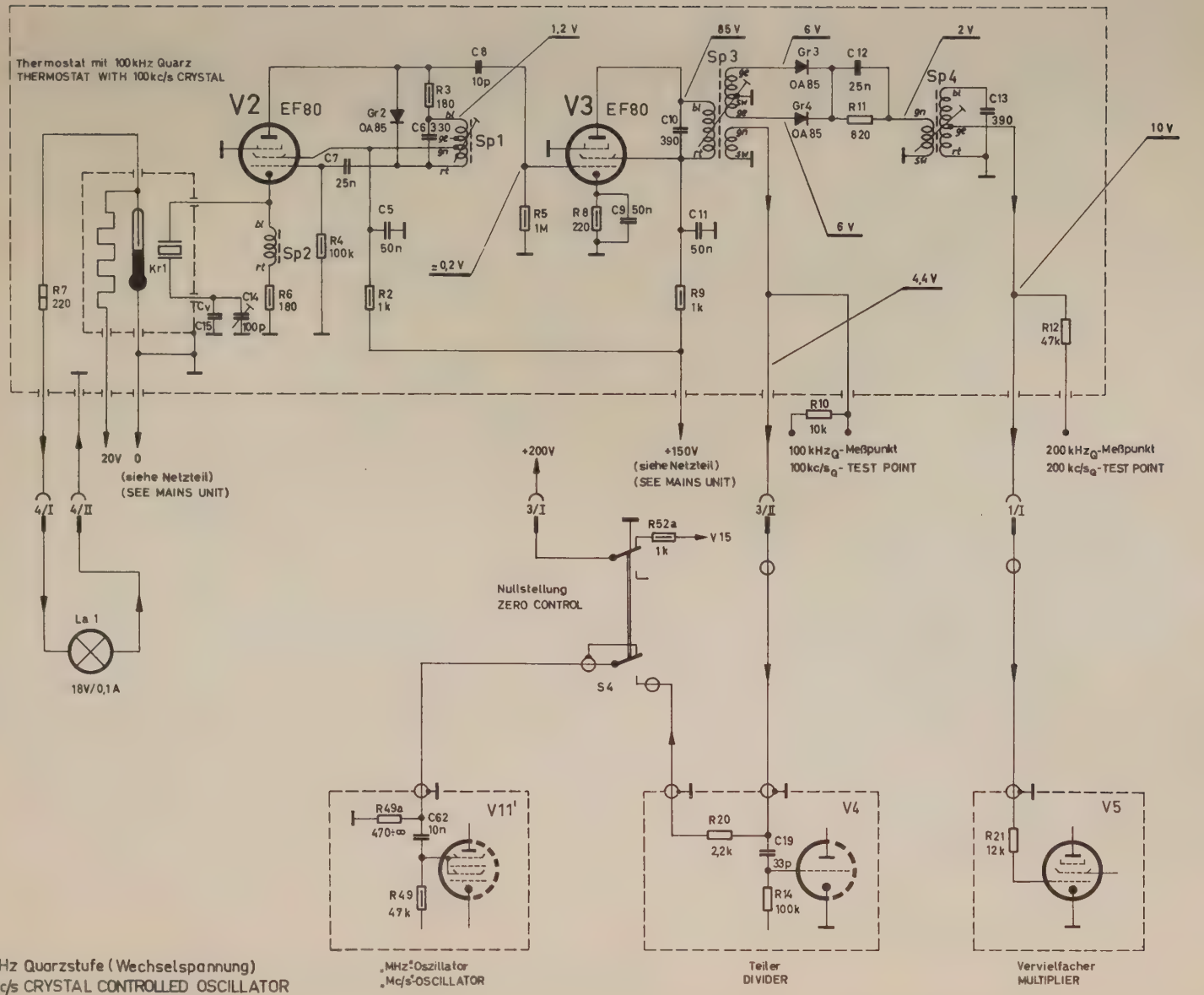


Bild 12 100kHz Quarzstufe (Wechselspannung)
FIG. 12 100kc/s CRYSTAL CONTROLLED OSCILLATOR (A.C. VOLTAGE)

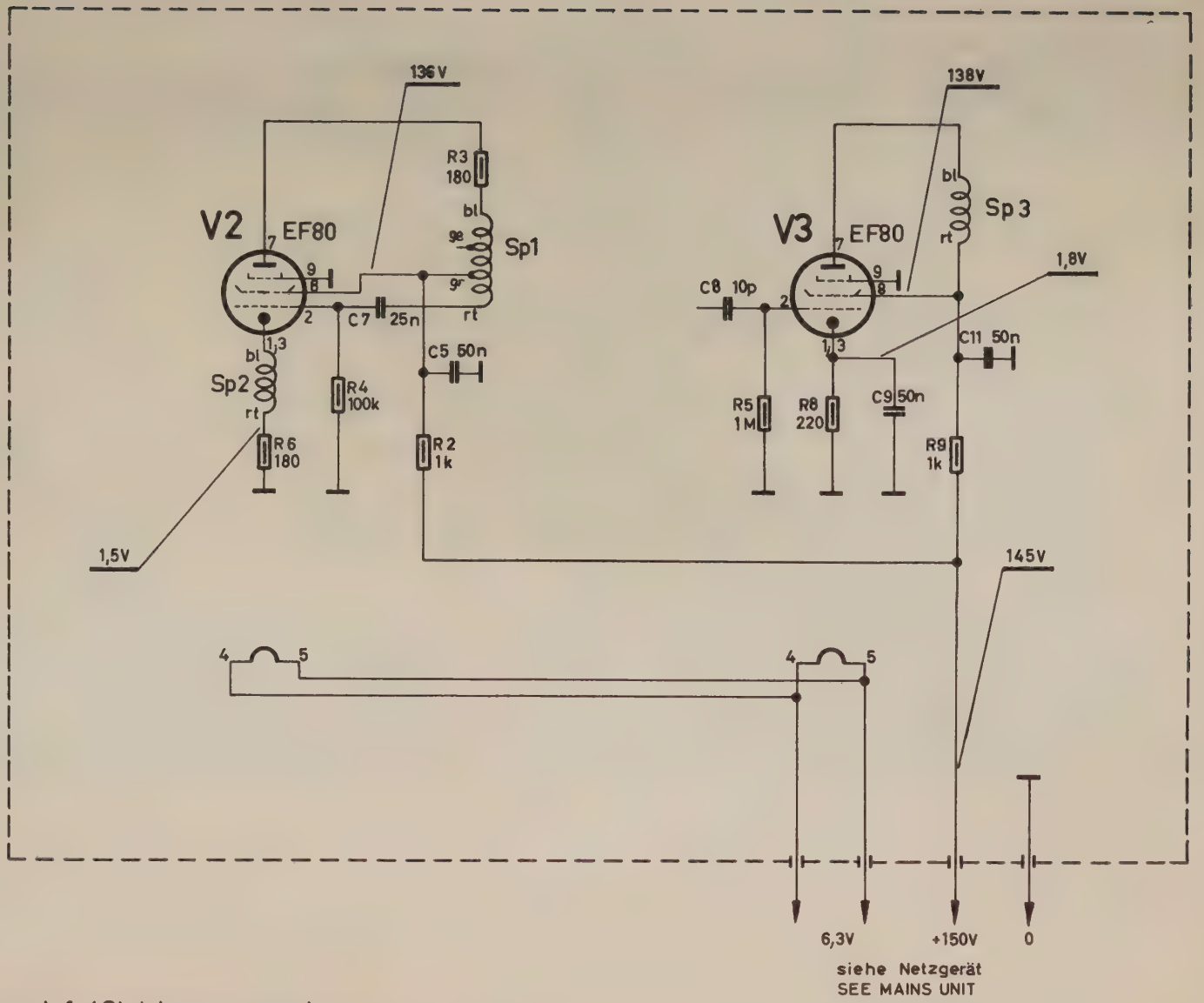


Bild 13 100kHz Quarzstufe (Gleichspannungen)
FIG. 13 100kc/s CRYSTAL-CONTROLLED OSCILLATOR (D.C. VOLTAGES)

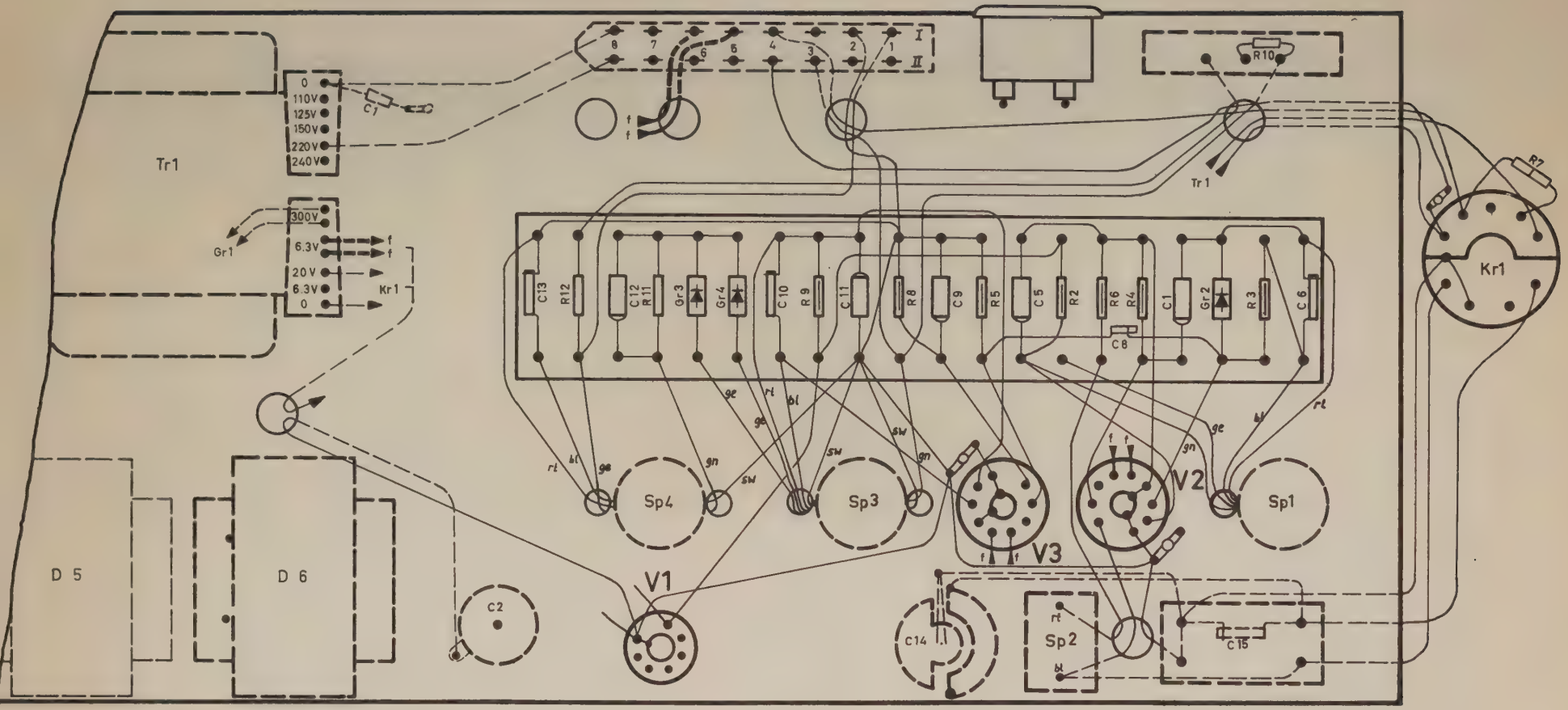


Bild 14 100 kHz-Quarzstufe (Verdrahtungsplan)
FIG. 14 100kc/s-CRYSTAL-CONTROLLED OSC. (WIRING DIAGRAM)

b) Multiplier

For the synchronisation of the "Mc/s" oscillator (main oscillator) with quartz crystal accuracy on every 1 Mc/s point over a range of 30 to 90 Mc/s, a spectrum of the following characteristics is required:

A spectrum consisting of the harmonics of a 1 Mc/s frequency, which are spaced at crystal-accurate intervals, over the range of 25 to 85 Mc/s, and have practically uniform amplitude.

Therefore, the multiplier serves to produce from the 100 kc/s standard (respectively 200 kc/s_Q) in stepwise multiplication (200 $kc/s_Q \rightarrow$ 1 $Mc/s_Q \rightarrow$ 5 $Mc/s_Q \rightarrow$ 20 Mc/s_Q) a frequency mixture that furnishes, after appropriate distortion (see "Mc/s" oscillator, Gr 12), the required standard frequency spectrum.

In addition, the multiplier furnishes a 5 Mc/s_Q frequency purified from 1 Mc/s_Q sidebands, which is used as a reference frequency in the "10 kc/s" oscillator.

The operation of this stage will now be described by means of the block diagram (Fig. 15) and the a-c voltage diagram (Fig. 16).

The 200 kc/s_Q frequency obtained from the resonant circuit Sp 4, C 13, is fed to the distorter tube V 5 via a multiple plug connection and a shielded lead. A bandpass filter (Sp 6, Sp 7) located in the plate circuit of the tube selects the fifth harmonic, i.e. 1 Mc/s_Q, and applies it to the second distorter tube (V 6), in the plate circuit of which is a fixed circuit tuned to 5 Mc/s. The resulting 5 Mc/s_Q frequency, which has some 1 Mc/s_Q sidebands, is applied to the third distorter stage (V 7) by capacitive coupling (C 35). To the plate circuit of this tube, a coil (Sp 22) is connected via a coupling capacitor and a concentric lead. Together with the inherent capacity of the concentric lead, this coil constitutes an oscillating circuit that has its maximum at 20 Mc/s. This maximum is of low amplitude due to the damping resistor (R 29) inserted in the plate circuit of tube V 7. This is quite intentional, in order not to attenuate the sidebands, which are required for the generation of the 1 Mc/s spectrum. The generation of this spectrum is described in Chapter 2. d) "Mc/s" oscillator.

The 5 Mc/s_Q frequency mentioned in the beginning, which is also obtained from the multiplier, is loosely coupled out (by C 34) from the 5 Mc/s circuit (Sp 8, C 31) located in the plate lead of tube V 6, and passed through a second 5 Mc/s filter circuit (Sp 9, C 36). Coils Sp 8 and Sp 9 form therefore a bandpass filter for 5 Mc/s. By this means, the 5 Mc/s_Q frequency obtained from coil Sp 9 is purified from the 1 Mc/s sidebands. The further application of this 5 Mc/s_Q frequency is described in Chapter 2. e), "10 kc/s" oscillator.

Test key "Mc/s test":

The key "Mc/s test" (S 6) serves to check the dial calibration of the "Mc/s" oscillator, by producing a 5 Mc/s spectrum for testing the dial calibration, instead of a 1 Mc/s spectrum, since it is not likely that the frequency should drift by 5 Mc/s. The procedure is the following:

In order to avoid the use of too much filter circuitry, the 5 Mc/s are not derived from the standard frequency, but obtained from the "10 kc/s" oscillator. As mentioned earlier, this oscillator covers the range 4.7 to 5.7 Mc/s. If the dial is set to "30 $\times$ 10 kc/s", the oscillator furnishes a frequency of 5 Mc/s.

This frequency passes through all the 5 Mc/s filters of the "10 kc/s" oscillator stage, is then obtained from coil Sp 10 and, when the test key is pressed, is applied to the grid of the distorter tube V 6. Since these 5 Mc/s are free of 1 Mc/s sidebands, a pure 5 Mc/s spectrum is formed, which is used to test and reset the Mc/s dial. The red calibration marks are located 300 kc/s off the dial markings, due to the necessary variation of the "10 kc/s" oscillator by 300 kc/s. Also, when pressing the test key (S 6), the plate voltage supplies for the distorter tube V 5 and the divider tube V 4 are interrupted at the same time.

On the enclosed a-c voltage diagram (Fig. 16) a number of voltages are shown which can be used as comparison values when making repairs. Of course, these values are only approximate ones, which may vary slightly in different equipments. They should be measured with a tube voltmeter of low input capacitance.

The voltages shown in the d-c voltage diagram (Fig. 17) are also only approximate values measured with a d-c voltmeter of an internal impedance of 50 k-ohms per volt.

The enclosed wiring diagram (Fig. 18) serves to facilitate the locating of circuit elements.

Calibrating instructions:

Bandpass filter (Sp 6, C 23; Sp 7, C 28):

Adjust to maximum voltage for a frequency of 1 Mc/s. Connect tube voltmeter to the blue terminal of coil Sp 6 via a coupling capacitor of about 1 pF and adjust core to maximum voltage indication. The same is done with coil Sp 7 and is repeated several times in turns.

Bandpass filter (Sp 8, C 31; Sp 9, C 36):

Adjust to voltage maximum for a frequency of 5 Mc/s. Connect tube voltmeter to yellow terminal of coil Sp 8 and adjust core to maximum voltage indication. Then connect tube voltmeter to green terminal of coil Sp 9 and adjust to maximum indication. Repeat several times in turns.

Note: The dimensioning of the coils is such that the cores should be flush with the ends of the coil formers when correct adjustment has been attained.

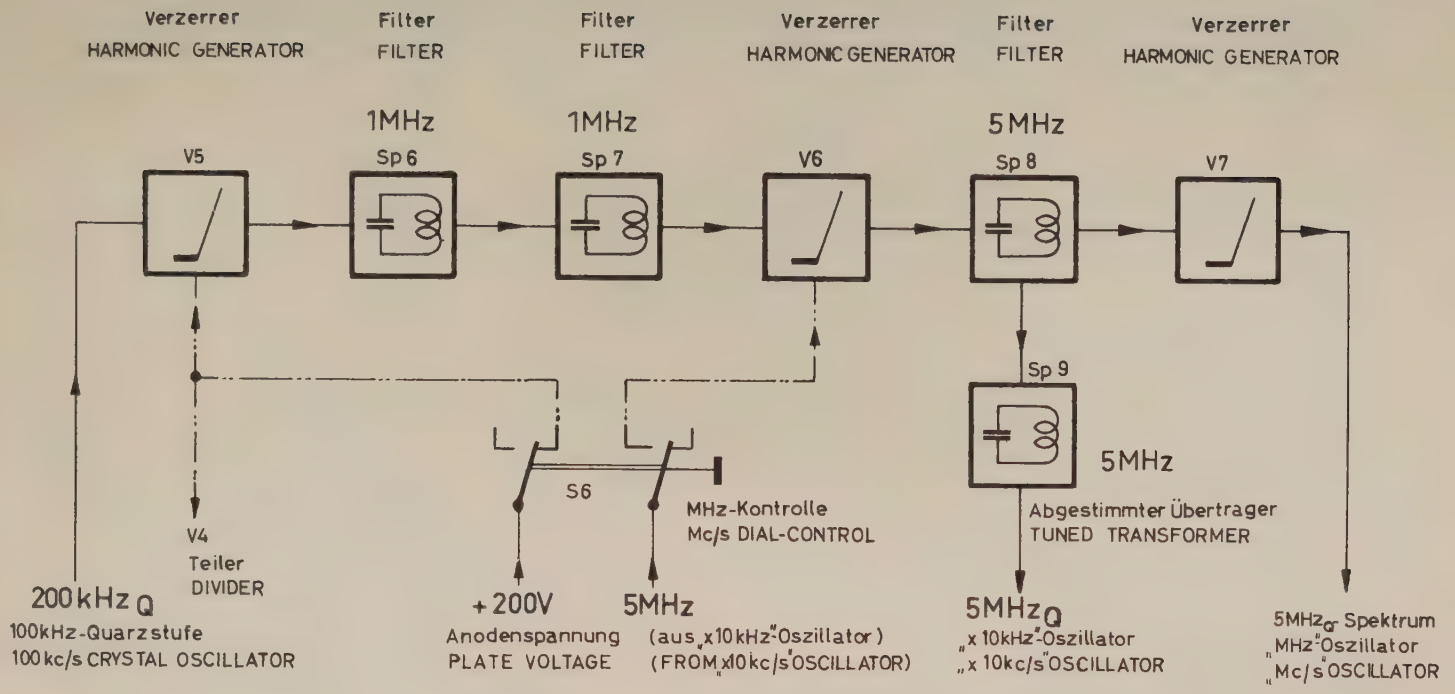


Bild 15 Vervielfacher (Blockschaltbild)
FIG. 15 MULTIPLIER (BLOCK DIAGRAM)

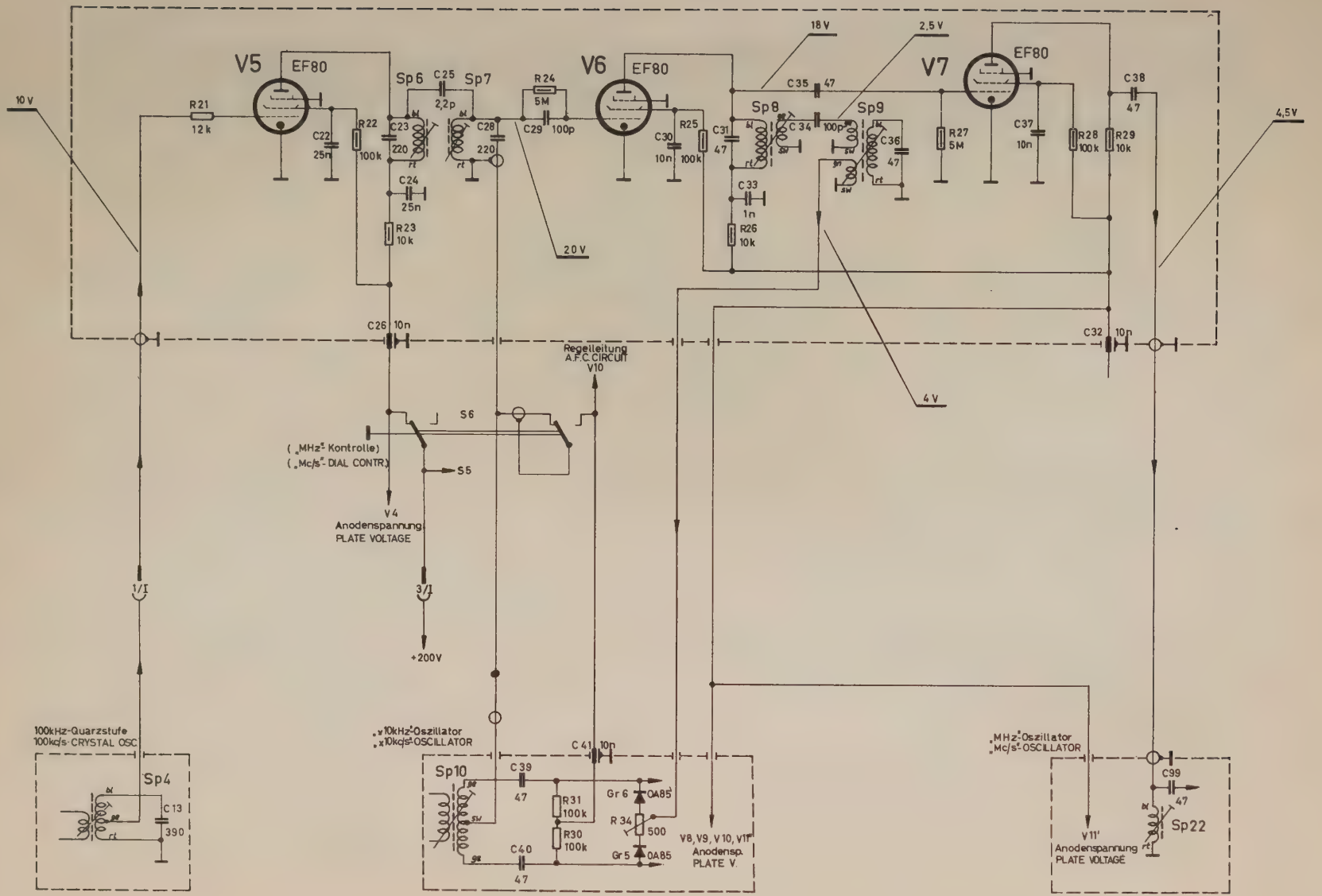


Bild 16 Vervielfacher (Wechselspannungen)
FIG. 16 MULTIPLIER (A.C. VOLTAGES)

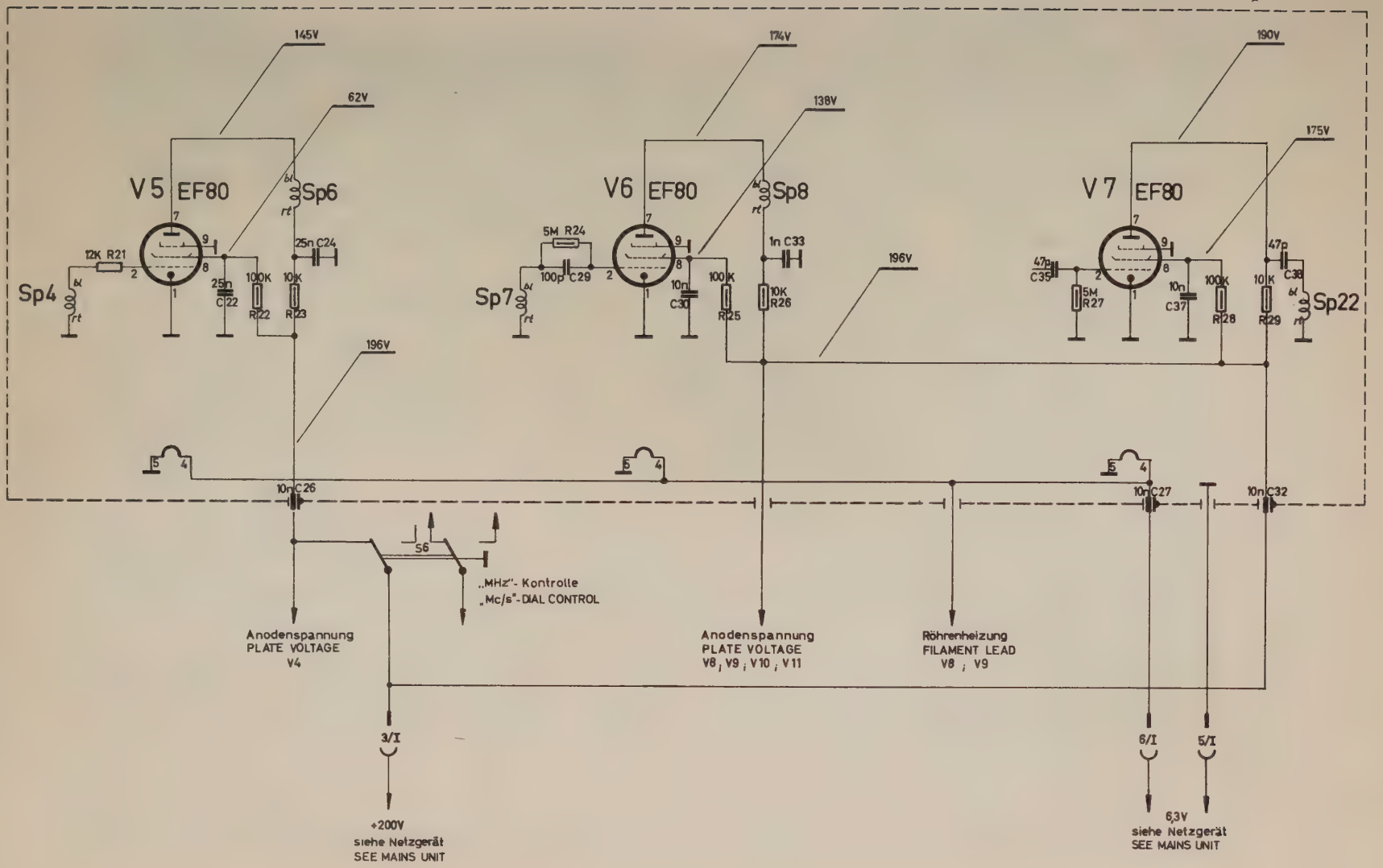


Bild 17 Vervielfacher (Gleichspannungen)
FIG. 17 MULTIPLIER (D.C. VOLTAGES)

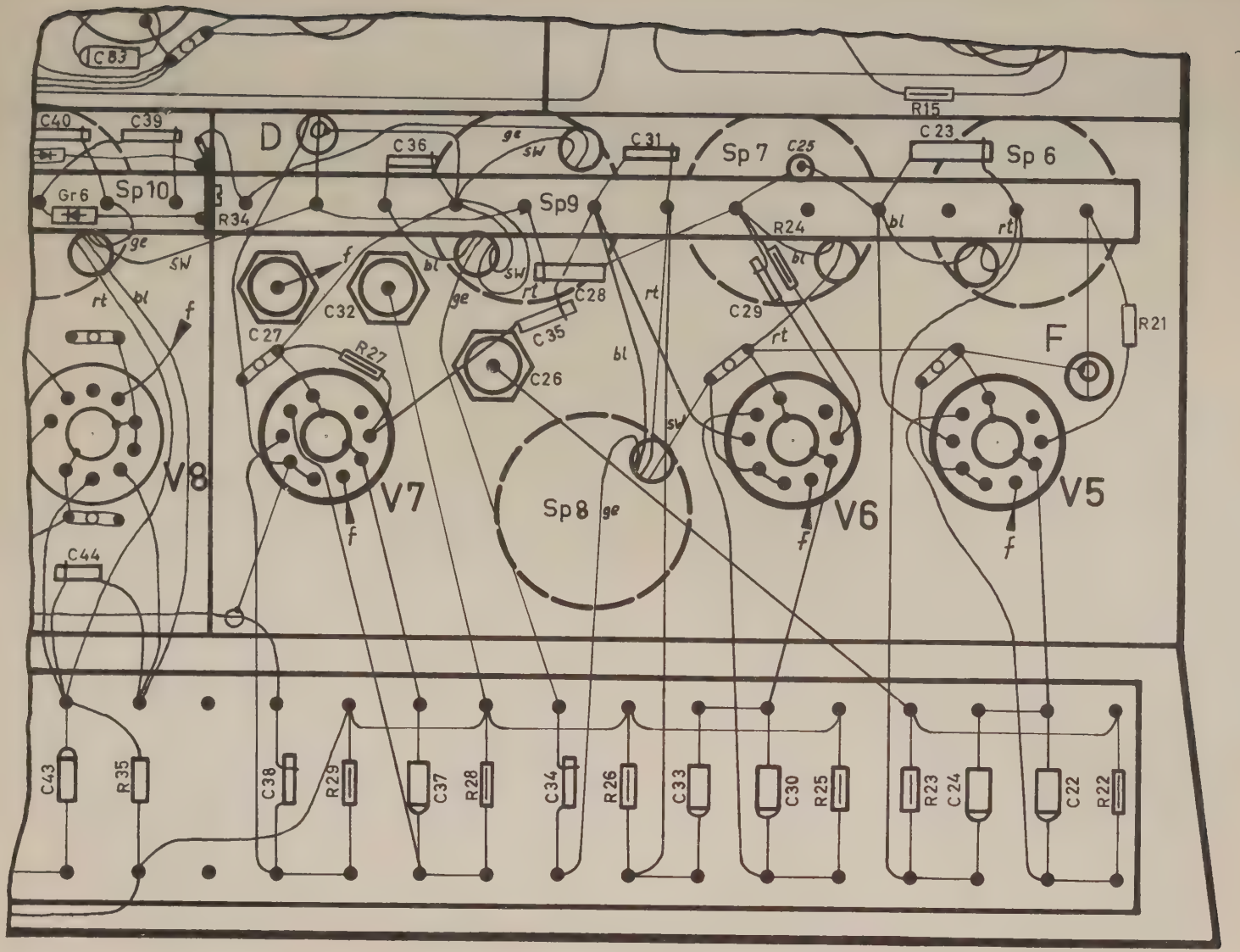


Bild 18 Vervielfacher (Verdrahtungsplan)
FIG. 18 MULTIPLIER (WIRING DIAGRAM)

c) Divider

In order to be able to synchronise the output frequency in steps of 20 kc/s, a standard frequency of 20 kc/s_Q must be produced.

This is done by means of the divider stage. It divides the 100 kc/s_Q supplied from the crystal oscillator, at a ratio of 5 : 1, into 20 kc/s_Q.

This stage will now be described by means of the block diagram (Fig. 19) and the a-c voltage diagram (Fig. 20).

The 100 kc/s_Q standard frequency obtained from the tuned transformer (Sp 3) of the 100 kc/s crystal oscillator is conducted via a multiple plug connection and a shielded lead, on the one hand to the grid of tube V 4, and on the other hand via a protective resistor (R 20) to the test key "ZERO TEST" (S 4). The purpose of this test key will be explained later.

The 5 : 1 divider (V 4) is a regenerative oscillator, the frequency of which is predeterminded by the resonant circuit Sp 5, C 20. It oscillates at a frequency of about 20 kc/s and is synchronised by 100 kc/s_Q. If the voltage of the 100 kc/s_Q is interrupted, the circuit will go on oscillating, at its own proper frequency.

The voltage of the 20 kc/s_Q is obtained at the cathode of tube V 4" and applied to the 10 kc/s oscillator stage via a coaxial cable. Besides, the 20 kc/s are obtained from another tapping of the 20 kc/s circuit (Sp 5, C 20) and applied to a test point. The location of this test point may be seen from the wiring diagram (Fig. 22).

Test key "ZERO TEST":

Within the divider stage, the supplied 100 kc/s_Q standard is branched off via a protective resistor (R 20) and applied to the test key S 4. When pressing this key, the blocking capacitor C 62 for the screen grids of tube V 11 is turned into a coupling capacitor for the 100 kc/s_Q frequency. At the same time, the plate voltage supply for the mixer tube V 15 is interrupted.

Tube V 11' operates as a distorter for the supplied 100 kc/s_Q frequency. The bandpass filter located in the plate circuit, which is tuned to 300 kc/s, selects the 3rd harmonic. For a detailed description see "Mc/s" oscillator.

Test key "10 kc/s test":

A further test key (S 5) is shown in the d-c voltage diagram (Fig. 21). When pressing this key, the plate voltage of the divider stage is cut off, so that the 20 kc/s_Q frequency is interrupted. This key serves for testing the calibration of the "x 10 kc/s" dial. For further details see chapter 2. e), "10 kc/s" oscillator.

The enclosed a-c voltage diagram (Fig. 20) shows some voltage values, which are however only approximate values and may vary in different equipments.

The same is applicable to the d-c voltage diagram (Fig. 21). The voltages should be measured with an instrument of 50 k-ohms/volt.

The enclosed wiring diagram (Fig. 22) serves to facilitate locating the circuit elements.

Calibrating instructions:

Oscillating circuit (Sp 5, C 20):

Disconnect the coupling capacitor C 19 on one side and adjust the proper frequency of the oscillator V 4 to 20 kc/s as sharply as possible by adjusting the core of coil Sp 5. Then perform frequency comparison by means of an oscilloscope in the following manner:

Connect one input of the oscilloscope to the 20 kc/s_Q test point, the other one to the 100 kc/s_Q test point. Adjust core of coil Sp 5 in such a manner that the oscilloscope screen shows a slowly turning Lissajous figure 5 : 1. Now solder C 19 back into place. The Lissajous figure should then come to standstill.

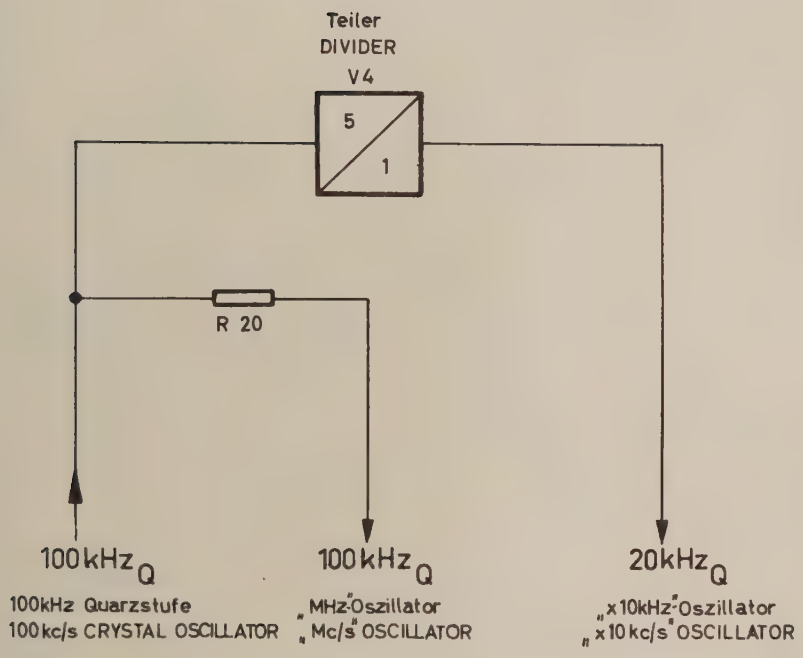


Bild 19 Teiler (Blockschaltbild)
FIG. 19 DIVIDER (BLOCK DIAGRAM)

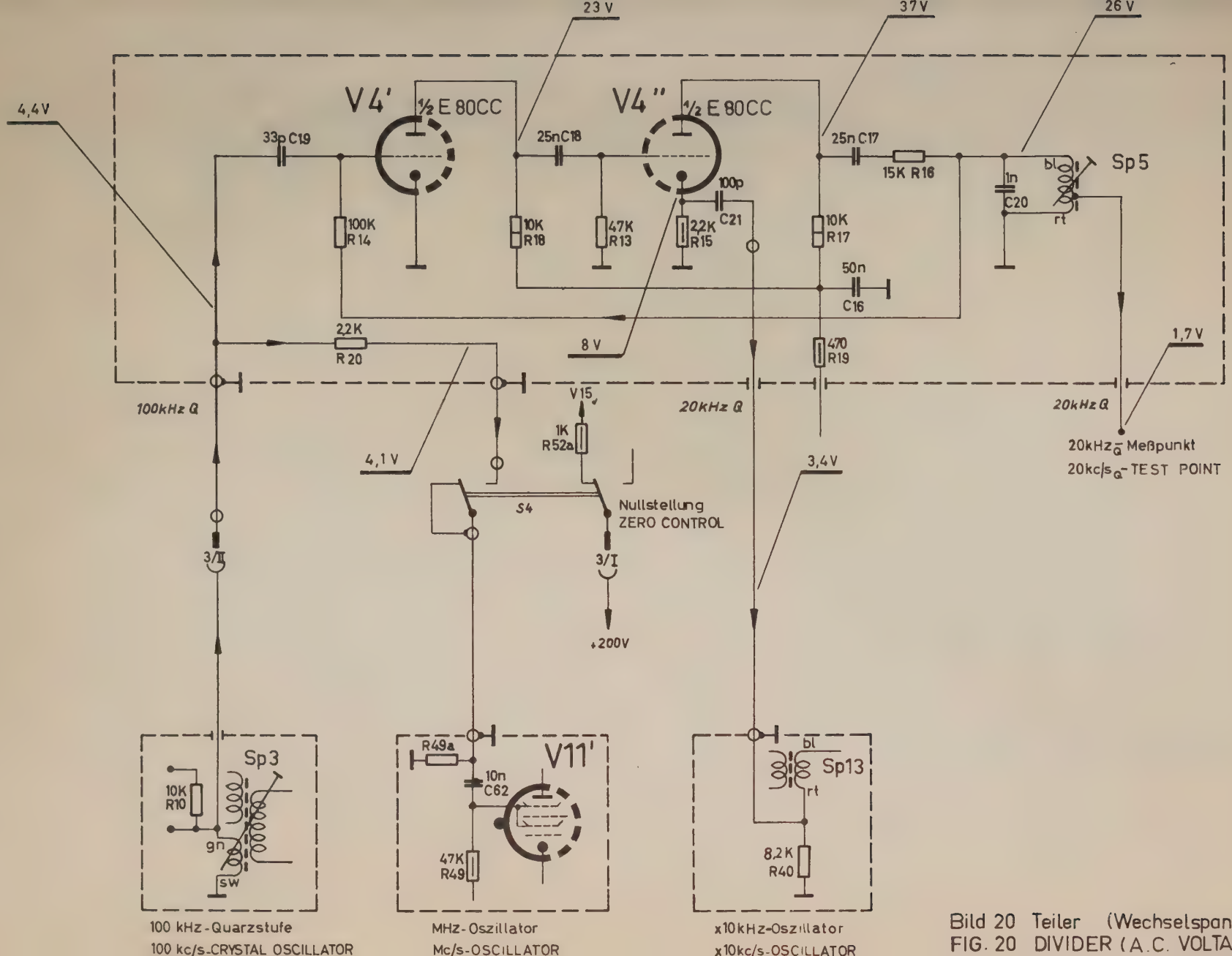


Bild 20 Teiler (Wechselspannungen)
FIG. 20 DIVIDER (A.C. VOLTAGES)

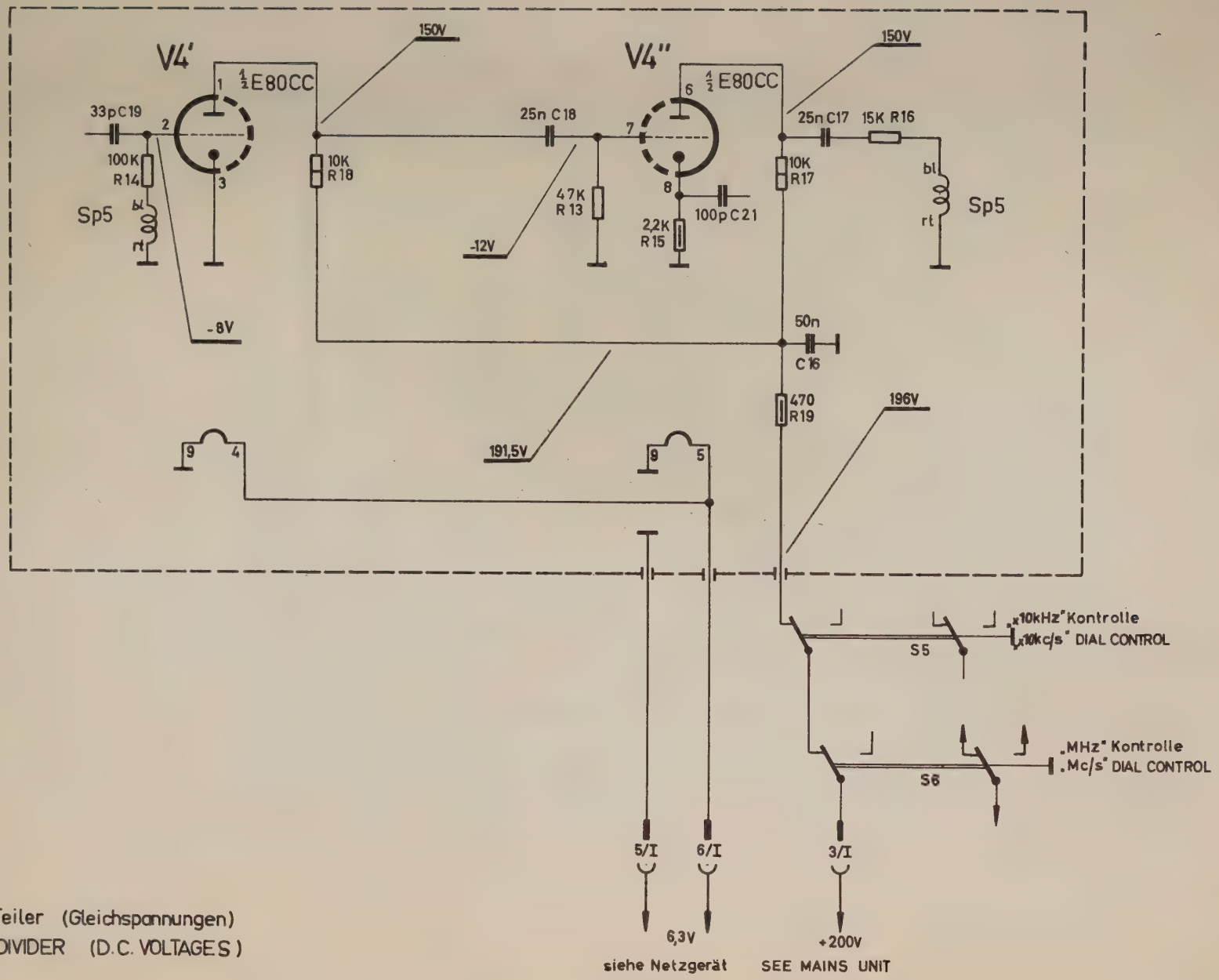


Bild 21 Teiler (Gleichspannungen)
FIG. 21 DIVIDER (D.C. VOLTAGES)

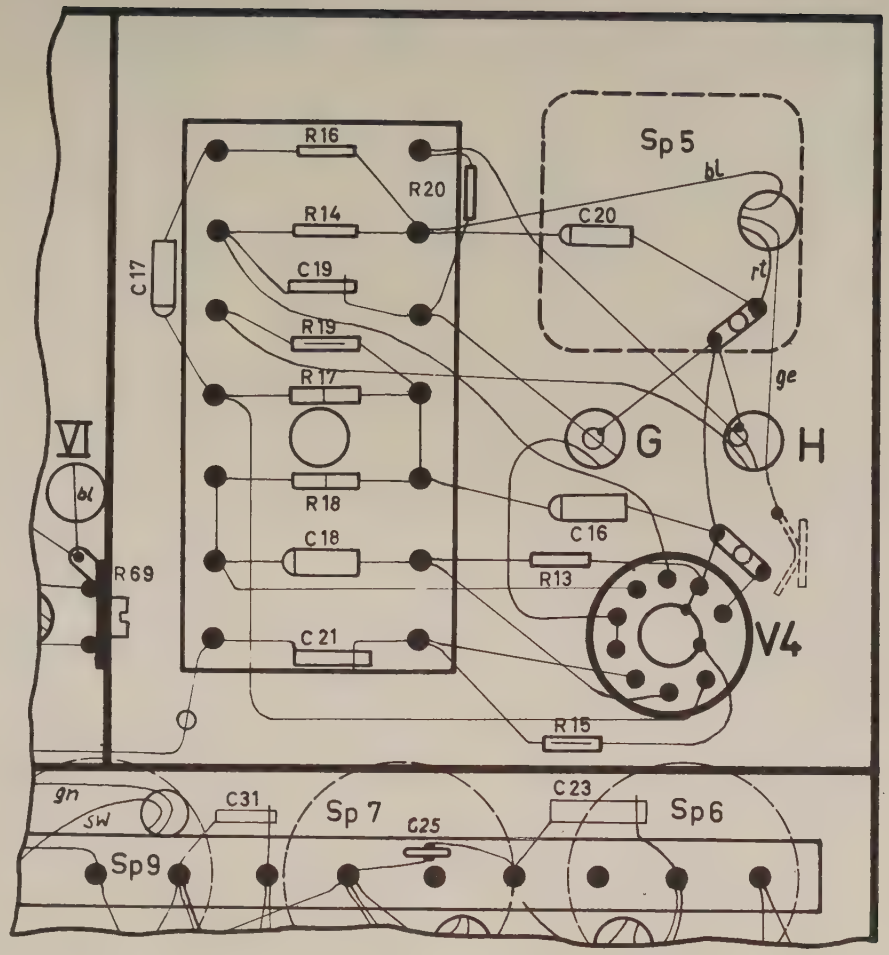


Bild 22 Teiler (Verdrahtungsplan)
FIG. 22 DIVIDER (WIRING DIAGRAM)

d) "Mc/s" oscillator (main oscillator)

This stage contains the oscillator that produces the output frequency proper of the FD 1 Frequency Meter. The circuitry described in this chapter enables this oscillator to be synchronised with an accuracy of ± 50 c/s.

The mode of operation of this stage will now be explained by means of the block diagram (Fig. 23) and the a-c voltage diagram (Fig. 24).

The oscillator circuit (Sp 29 through Sp 31, C 114) is excited in an ECO circuit. Its ranges of variation are:

Range 1: 30 to 43 Mc/s
Range 2: 42 to 61 Mc/s
Range 3: 60 to 92 Mc/s

The oscillator frequency is obtained at the plate of the oscillator tube (V 17) and applied to a distorter diode (Gr 14) via C 117. The distorted fundamental frequency and its harmonics are conducted to the output socket Bu 3 via C 118. For passive measurements, this output socket (Bu 3) serves as an input for frequencies above 30 Mc/s. Here, the distorter diode (Gr 14) serves as a mixer at the same time.

The difference frequency formed that way is connected to the multiple plug connection via C 119 and a shielded lead, and from there to the grid of the AF amplifier tube V 19.

For passive frequency measurements below 30 Mc/s, a second input socket (Bu 2) has been provided ("fx < 30 Mc/s"), which conducts the frequency to a circuit where its harmonics are formed (distorter diode Gr 13) and applied to the mixer diode Gr 14 to form the difference frequency.

A reactance tube (V 16) is connected in parallel to the oscillating circuit, which varies the oscillating circuit and therefore its frequency in dependence on its operating point. This control process will be explained later. The reactance tube is controlled via phase shifter elements (D 1 to 3, R 77) by means of the oscillator frequency.

The variable resistor (R 78) located in the cathode circuit of the reactance tube (V 16) is used for the fine adjustment of the "Mc/s" oscillator frequency. A variation of the operating point of the reactance tube results also in a variation of the resonance frequency of the oscillating circuits Sp 29 through Sp 31, C 114. The pointer knob controlling this fine adjustment is located below the Mc/s dial.

The circuitry used for the synchronisation (AFC) of the main oscillator will now be described.

The voltage of the oscillator frequency (30 to 90 Mc/s) is obtained from the cathode of the oscillator tube (V 17) and put across the first grid of the mixer tube V 15. A portion of the cathode resistance (R 73) is used as a grid leak.

A standard frequency that differs from the oscillator frequency by 5 Mc/s (5 to 6 Mc/s) is applied to the third grid of the mixer tube (V 15). This standard frequency is selected from a 1 Mc/s_Q spectrum (25 to 85 Mc/s), which is generated in the following manner:

A distorted 5 Mc/s_Q frequency that has some 1 Mc/s_Q sidebands is obtained from the multiplier stage and applied to the 20 Mc/s tuned circuit (Sp 22). The distorter diode Gr 12 produces the desired spectrum. A variable filter (Sp 23 to Sp 28) that is ganged to the tuning of the oscillating circuit (Sp 29 to Sp 31) at a frequency difference of 5 Mc/s, selects that standard frequency from the spectrum which is located by 5 Mc/s (5 to 6 Mc/s) below the momentaneous oscillator frequency.

A variable filter of 5 to 6 Mc/s is located in the plate circuit of the mixer tube V 15. Supposing that this filter is tuned to 5 Mc/s, a frequency of 5 Mc/s will appear at the grid of the mixer tube V 11 each time that the oscillator (C 114) is varied by another 1 Mc/s, when varying the oscillator throughout its range. The voltage of the oscillator frequency of the "10 kc/s" oscillator is placed across the third grid of the mixer tube V 11'. As mentioned above, this frequency can be adjusted with fixed phase every 20 kc/s over the range 4.7 to 5.7 Mc/s.

The variable filter (Sp 14, Sp 15) covering the band 5 to 6 Mc/s is ganged with the tuning of the "10 kc/s" oscillator at a frequency difference of 300 kc/s.

Therefore, when varying the oscillator circuit (C 114, Sp 29 to Sp 31), a frequency of 300 kc/s will be available at the plate of the mixer tube V 11', each time that the oscillator is varied by another 1 Mc/s. This frequency is not dependent on the position of the "10 kc/s" oscillator.

With the circuit arrangement described so far, the frequency of the oscillator V 17 can only be adjusted in steps of 20 kc/s with high accuracy. The arrangement used to cover these 20 kc/s intervals in continuous tuning will be described later, but it should be mentioned now that this variation by 0

to 20 kc/s influences of course the difference frequency of 300 kc/s. This frequency is varied from 300 to 320 kc/s, when the fine tuning dial is varied by 0 to 20 kc/s. Therefore, the bandpass filter inserted in the plate circuit of the mixer tube V 11′ has a bandwidth of 20 kc/s.

A transformer (Sp 18) tuned to 300 kc/s and having a bandwidth of 20 kc/s is located in the plate circuit of the amplifier tube V 12, in parallel to two limiter diodes (Gr 7, Gr 8), which limit the amplitude of the 300 kc/s voltage and, therefore, keep the voltage at the secondary of the transformer reasonably constant.

The two diodes (Gr 9, Gr 10) at the control grid of the next-following amplifier tube (V 13) serve the same purpose. The reason why the voltage has to have a constant value is the following:

A discriminator circuit is inserted in the plate circuit of the second amplifier circuit (V 13). This discriminator circuit may be varied by + 20 kc/s from its zero position (300 kc/s → 320 kc/s). This variation takes place on the linear portion of the discriminator characteristic and therefore the calibration characteristic of the fine tuning dial is linear. If now the control voltage across the control grid of the amplifier tube (V 13) were to change, this would affect the linearity of the discriminator characteristic and, therefore, that of the fine tuning dial.

A transformer (Sp 19) tuned to 300 kc/s for the discriminator circuit is inserted in the plate circuit of the amplifier tube (V 13). The variation of 0 to 20 kc/s (from 300 to 320 kc/s) is done by means of the tuning circuit Sp 20 (Sp 21), C 86, which is coupled to the circuit by C 85 (90° phase shift). Coil Sp 21 is accessible from the front panel and serves for the zero adjustment of the fine tuning dial (see page 21).

From a tapping on coil Sp 20, the 300 to 320 kc/s a-c voltage is fed into the discriminator (phase bridge) on the one hand, and on the other hand it is rectified by means of the diode Gr 11 and supplied to the magic eye (V 18) as an indicating voltage.

The mode of operation of the discriminator will now be explained:

A reactance tube (V 16) is connected in parallel to the oscillator circuit (C 114, Sp 29 to Sp 31). If the operating point is shifted (by increasing or decreasing the bias at the control grid), the frequency of the oscillator will change accordingly.

This bias is produced by the discriminator as soon as the converted oscillator frequency (300 to 320 kc/s) differs from the proper resonant frequency of the fine tuning circuit (Sp 20, Sp 21, C 86).

The resulting phase difference between the voltage from Sp 19 and the voltage from Sp 20 produces a control voltage. Since these two voltages have a relative phase angle of 90° for a control voltage of ± 0, a variation will result in either a positive or a negative control voltage (see page 19).

This voltage is a d-c voltage and is indicated on the instrument J 2. It is conducted via R 54 to the time constant C 106 and then to the control grid of the reactance tube V 16. The oscillator frequency is then varied by V 16 in such a way that it approaches the resonant frequency of the fine tuning circuit (Sp 20, Sp 21, C 86) as far as possible. The remaining difference in either sense is shown by the instrument J 2. A deflection of about 1 mm off center zero corresponds to approx. 30 c/s. This remaining inaccuracy can be eliminated by readjusting the Mc/s dial, (instrument pointer must be on center zero).

The above presentation shows that the relative phase angle between the two voltages coming from coil Sp 19 and from the tuning circuit (Sp 20, Sp 21, C 86) is essential for the accuracy of the frequency of the main oscillator (V 17). Therefore, when the fine tuning dial is set to zero, the relative phase angle of these two voltages must be exactly 90°, (instrument pointer of J 2 on center zero). In order to be able to check this condition, a standard frequency of 300 kc/s must be produced and supplied to the phase discriminator. This is done by pressing the test key "ZERO TEST" (S 4), so that the 90° phase angle of the variable discriminator can be checked and, if necessary, be readjusted by means of coil Sp 21 ("ZERO RESET").

Test key "ZERO TEST":

When pressing this key (S 4), the blocking capacitor C 62 of the screen grids of tube V 11′ is turned into a coupling capacitor for the 100 kc/s_Q frequency. This frequency is obtained via the divider stage (R 20) from the 100 kc/s_Q crystal oscillator stage. At the same time, the plate voltage supply for the mixer tube V 15 is interrupted.

Tube V 11′ operates as a distorter for the supplied 100 kc/s_Q frequency. The bandpass filter located in the plate circuit, which is tuned to 300 kc/s, selects the 3rd harmonic. The 300 kc/s_Q are amplified and used for testing the zero point of the fine tuning dial.

The voltage values shown in the a-c voltage diagram (Fig. 24) should be measured with an appropriate tube voltmeter of low input capacitance. They are only approximate values which may vary with different dial settings and also in the individual equipment.

The same is applicable to the voltages shown in the d-c voltage diagram (Fig. 25). These voltages should be measured with a d-c voltmeter of an internal impedance of 50 k-ohms/volt.

The enclosed wiring diagram (Fig. 26) serves to facilitate locating the circuit elements.

Calibrating instructions:

Oscillating circuit (Sp 29 to Sp 31):

Adjust variable resistor R 78 to center position.

Range 3: At the upper end of the dial (92 Mc/s), adjust the output frequency of the oscillator to be identical with the dial indication, by means of trimmer C 113.

Adjust lower end of dial (60 Mc/s) to be identical with the output frequency of the oscillator, by means of the core of coil Sp 31.

Range 2: Proceed as above, at upper end of dial (61 Mc/s), by means of trimmer C 130.

At lower end (42 Mc/s), by means of coil Sp 30.

Range 1: As above, at upper end of dial (43 Mc/s), by means of trimmer C 131.

At lower end (30 Mc/s), by means of coil Sp 29.

Taking turns, this process is repeated until the dial indication is identical with the actual output frequency of the oscillator in all ranges.

Variable bandpass filter (Sp 23 to Sp 28):

This filter, also called spectrum filter, is adjusted in one process together with the oscillating circuit (Sp 29 to Sp 31). The correct adjustment of the first filter circuit (C 97, Sp 23 to Sp 25) is by 5 Mc/s, that of the second one (C 95, Sp 26 to Sp 28), by 6 Mc/s, lower than the oscillator frequency.

In range 3, the adjustment of the trimmers (C 98, C 94) should be done at the upper end of the dial (92 Mc/s). The coils (Sp 25, Sp 28) should be adjusted at the lower end of the dial (60 Mc/s).

In range 2, the trimmers C 140 and C 137 are adjusted at the upper end of the dial (61 Mc/s), the coils Sp 24, Sp 27, at the lower end of the dial (42 Mc/s).

Range 1 is adjusted in the same manner: Upper end:—trimmers C 139 and C 138, (43 Mc/s), lower end:—coils Sp 23 and Sp 26, (30 Mc/s).

Tuned circuit (Sp 22, inherent C):

Adjust this circuit to maximum at 20 Mc/s by means of the core of coil Sp 22.

Variable bandpass filter (Sp 14, Sp 15):

This filter is adjusted simultaneously with the oscillating circuit (Sp 12, C 60) (page 32). Here, the frequency of the filter should be by 310 kc/s higher than that of the oscillating circuit. Adjust to 6 Mc/s with trimmers C 71, C 66, and to 5 Mc/s by means of the cores of coils Sp 14, Sp 15.

Bandpass filter (Sp 16, Sp 17):

Adjust to maximum at 310 kc/s by means of trimmers C 75, C 77.

Tuned transformer (Sp 18, C 80):

The amplifier tube V 12 is so driven that the diodes Gr 7, Gr 8, do not yet produce any limiting effect. Then adjust trimmer C 80 to maximum at 310 kc/s.

Tuned transformer (Sp 19, C 84):

Adjust to maximum at 300 kc/s by means of trimmer C 84.

Variable circuit (Sp 20, Sp 21, C 86):

Adjust coil Sp 21 ("ZERO RESET") to center position. Set fine tuning dial to zero and adjust to maximum deflection at 300 kc/s by means of the core of coil Sp 20 (voltmeter to C 89). Now adjust regulator R 69 so that the instrument J 2 shows no deflection. Set fine tuning dial to 20 kc/s and adjust to maximum deflection at 320 kc/s, by means of the trimmer C 88, (meter across C 89). Repeat the two processes until the dial is correctly calibrated.

Note:

If it is necessary to do a complete realignment of the equipment, it should be done in such a way that all the coils are realigned successively, starting out from the crystal oscillator. This has the advantage that the instrument J 2 and the magic eye (V 18) can be used as indicating instruments. Further suggestions as to how the equipment can be realigned without the help of measuring gear are given at the end of Section C, Servicing instructions.

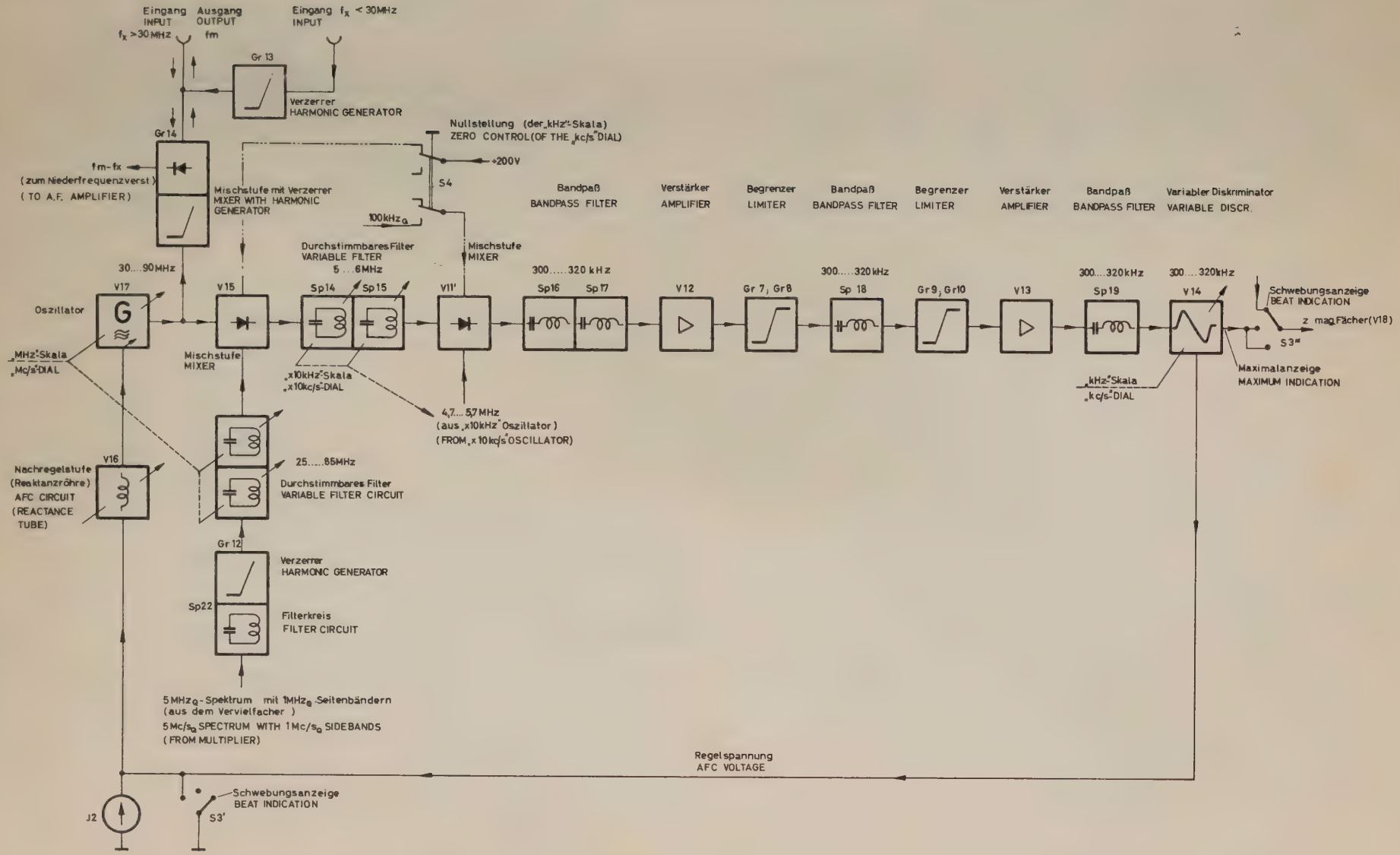


Bild 23 „MHz"-Oszillator (Blockschaltbild)
FIG.23 „Mc/s"-OSCILLATOR (BLOCK DIAGRAM)

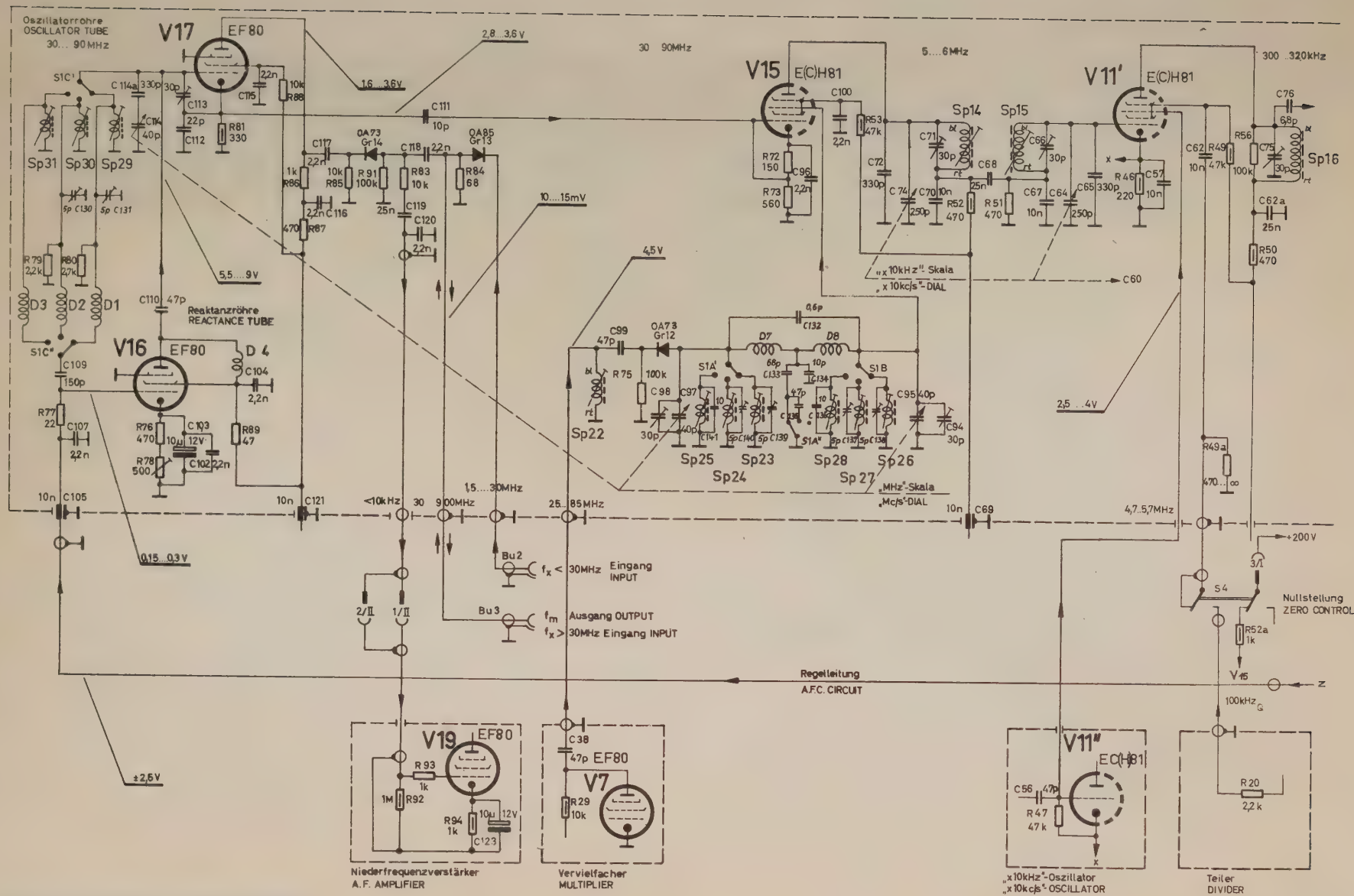


Bild 24a „MHz"-Oszillator (Wechselspannungen)
FIG. 24a „Mc/s"-OSCILLATOR (A.C. VOLTAGES)

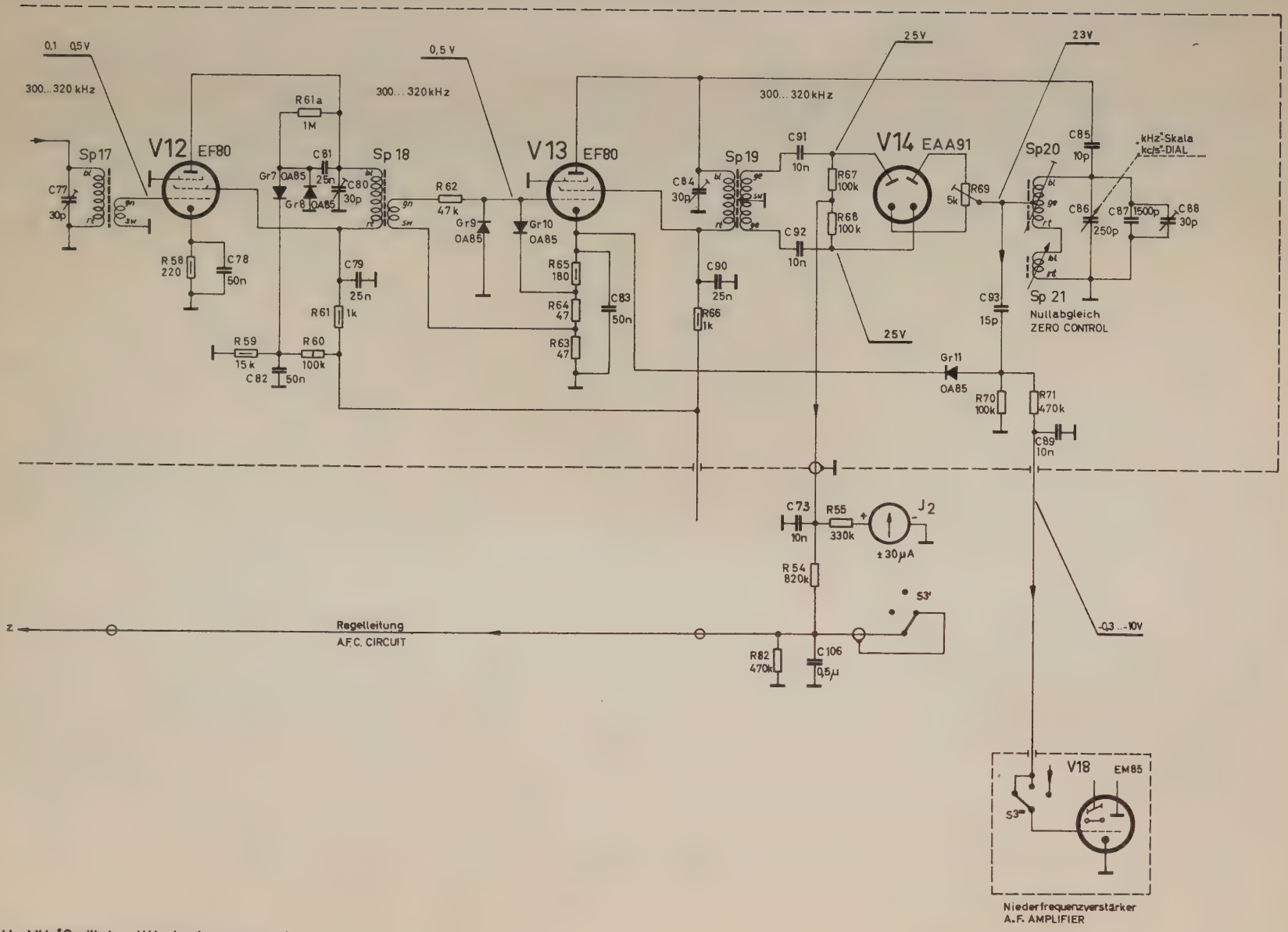


Bild 24b „MHz"-Oszillator (Wechselspannungen)
FIG. 24b „Mc/s"-OSCILLATOR (A.C. VOLTAGES)

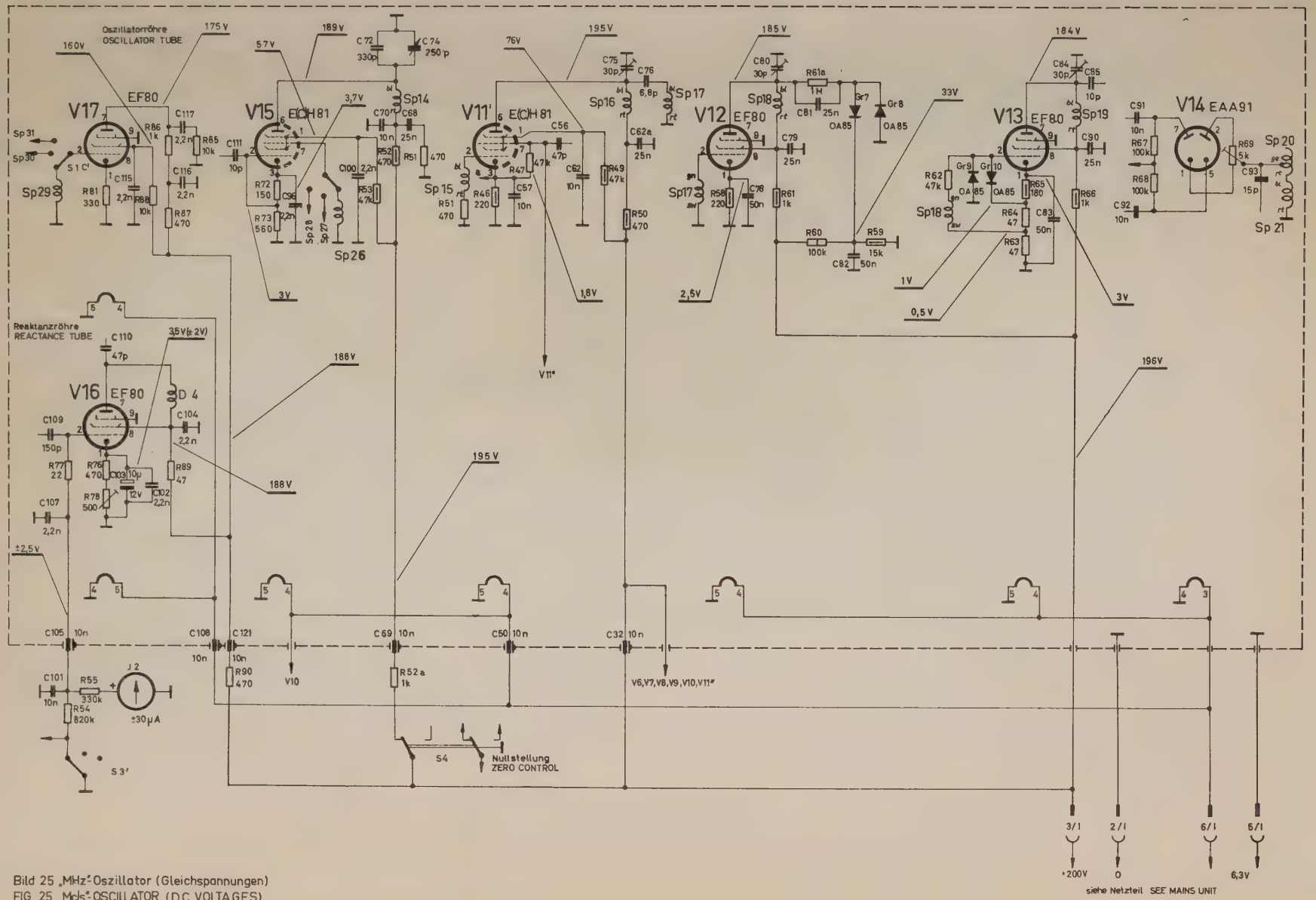


Bild 25 „MHz"-Oszillator (Gleichspannungen)
FIG. 25 „Mc/s"-OSCILLATOR (D.C. VOLTAGES)

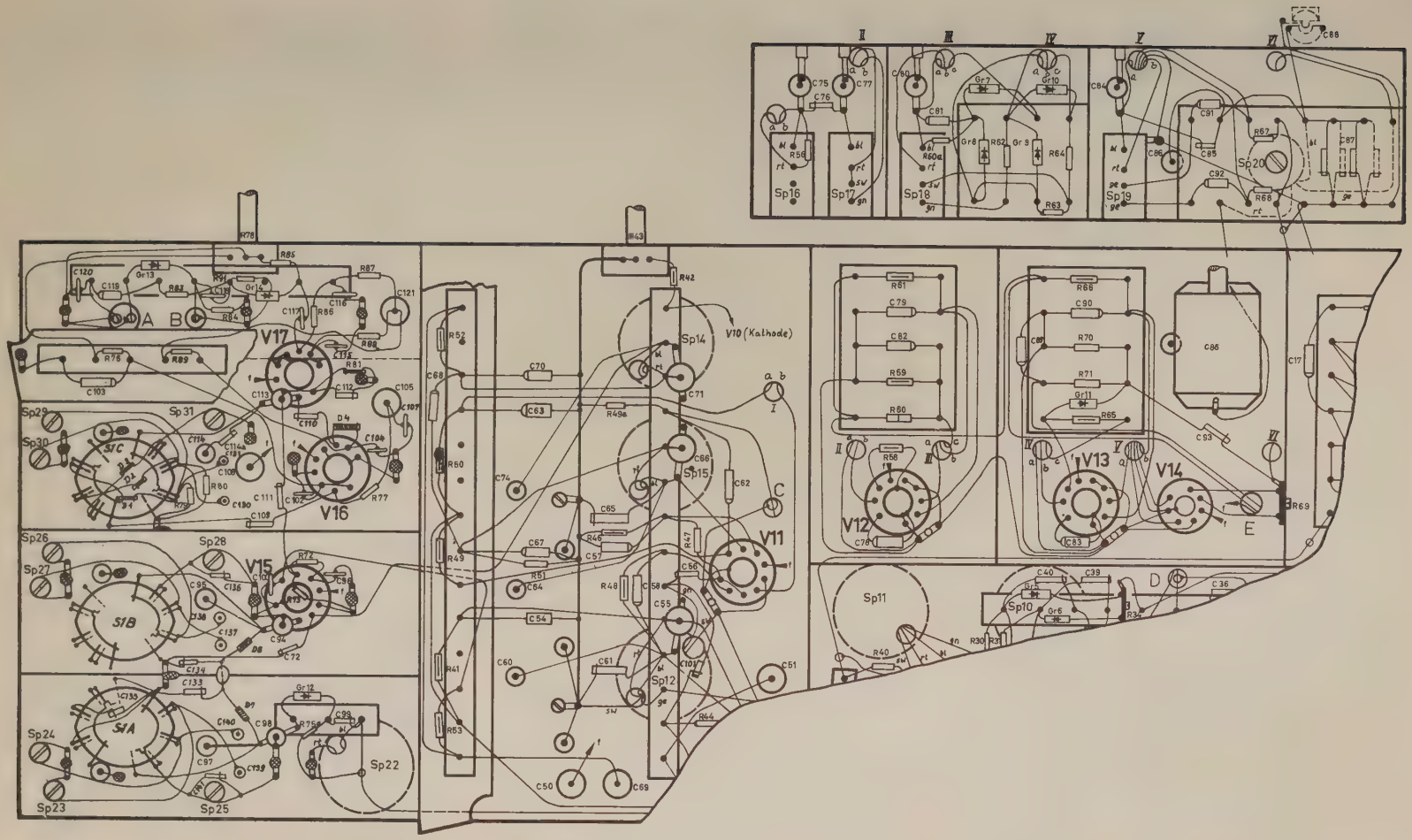


Bild 26 „MHz"-Oszillator (Verdrahtungsplan)
FIG. 26 „Mc/s"-OSCILLATOR (WIRING DIAGRAM)

e) "10 kc/s" oscillator (vernier oscillator)

This oscillator serves to generate a variable frequency of 4.7 to 5.7 Mc/s, which can be synchronised in phase with the 100 kc/s standard, in steps of 20 kc/s. It is called "10 kc/s" oscillator because it is controlled by the "10 kc/s dial" and the calibration marks of that dial are in the order of 10 kc/s.

The use of the output frequency of this oscillator has already been explained in Chapter d), Mc/s oscillator. Its mode of operation will now be described by means of the block diagram (Fig. 27) and the a-c voltage diagram (Fig. 28).

The oscillator is constituted by the triode section of tube V 11 (ECH 81). The R-C combination in the plate circuit of the oscillator tube enforces the effect of the reactance tube V 10. The voltage of the oscillator frequency shifted in phase by 90°, which is required for the control of the reactance tube V 10, is obtained from the feedback winding and put across the control grid of tube V 10 via the phase shifter element C 101, R 44.

The variable capaciter C 60 (10 kc/s dial) permits a variation of the oscillator frequency from 4.7 to 5.7 Mc/s. Also mounted on the same axle as the variable capacitor C 60 are the tuning capacitors C 64 and C 74, which adjust the resonance frequency of the variable filter Sp 14, Sp 15, (see "Mc/s" oscillator), in ganging with the oscillator frequency.

The frequency of 4.7 to 5.7 Mc/s obtained from the oscillator coil (Sp 12) is supplied to a wideband transformer where its voltage is stepped up. The standard frequency of 20 kc/s_Q is fed in in series with the secondary. The following tube (V 9) operates as a keyed modulator. Here, the tube V 9 is highly biased by the momentaneous frequency of 4.7 to 5.7 Mc/s (R 39) so that it is blocked. The 20 kc/s_Q frequency fed in at the grid in series keyes now tube V 9 during the positive half-cycle. As a result, the oscillator frequency (4.7 to 5.7 Mc/s) has a number of upper and lower sidebands spaced 20 kc/s_Q apart.

The transformer inserted in the plate circuit of tube V 9 is tuned to 5 Mc/s. When the oscillator frequency (V 11") is varied from 4.7 to 5.7 Mc/s (by varying the dial from "0" to "100 × 10 kc/s"), the filter Sp 11, C 47, will select a 5 Mc/s frequency every time that the oscillator has been varied by another 20 kc/s_Q. The voltage of this 5 Mc/s frequency is amplified in the following amplifier and the frequency is stabilised by a second tuned transformer (Sp 10, C 44) inserted in the plate circuit.

This 5 Mc/s frequency is then compared in the next-following phase discriminator (Gr 5, Gr 6) to the 5 Mc/s_Q secondary standard obtained from the multiplier. If the two frequencies are not identical, a control voltage is produced that pulsates at the rate of their difference frequency. When the short-circuit in the control lead (switch S 3" in position "SEARCH") is eliminated (switch S 3" in position "MEASURE" or "BEAT IND."), this pulsating control voltage will wobulate the oscillating circuit, and therefore the frequency of the oscillator, by means of the reactance tube (V 10) until the two frequencies compared at the phase discriminator (Gr 5, Gr 6) become identical or are locked into a rigid phase relation. The remaining phase difference is indicated as a d-c voltage by the instrument J 1.

Naturally, the operating point of the reactance tube (V 10) influences the oscillating circuit Sp 12, C 60, and therefore the dial calibration. Therefore, if tube V 10 is replaced by a new one or if it ages, the operating point has to be readjusted, in order to avoid dialing errors. For this purpose, a variable resistor (R 43) has been inserted in the cathode circuit of tube V 10, which is accessible on the front panel, below the "10 kc/s dial", by means o fa screw driver.

Test key "10 kc/s test":

A test key (S 5) is located to the left of the 10 kc/s dial for testing the dial calibration. When this key is pressed, the plate voltage of the divider tube V 4 is interrupted, so that the 20 kc/s_Q frequency is interrupted, too. Therefore, the oscillator frequency does not have any 20 kc/s_Q sidebands and the only frequency that is let through by the 5 Mc/s filter to produce a control voltage (synchronisation point) by means of the phase discriminator (Gr 5, Gr 6), is the 5 Mc/s oscillator frequency. This 5 Mc/s frequency corresponds to the dial point "30 × 10 kc/s" (marked by a red dot).

Test key "Mc/s test":

A test key (S 6) for testing the dial calibration of the Mc/s dial is located to the left of the Mc/s dial. This key serves to change the 1 Mc/s spectrum (1 Mc/s synchronisation points) into a 5 Mc/s spectrum. This is done in the following manner (see Fig. 28):

When the key is pressed, the plate voltage supplies for tubes V 4 and V 5 are interrupted, while at the same time the capacitor C 28 of the 1 Mc/s filter is separated from its grounding point and connected as a coupling capacitor. Also, the grounded center tapping of the secondary of Sp 10 is disconnected from the ground.

Before testing the calibration of the Mc/s dial, the 10 kc/s dial must be set to position "30 × 10 kc/s" (marked by a red dot) (output of the vernier oscillator: 5 Mc/s). This 5 Mc/s frequency is now obtained at the center tapping of coil Sp 10 and put across the grid of tube V 6 via the capacitor C 28. The purpose of this procedure is to get an unequivocal 5 Mc/s_Q secondary standard frequency. The 5 Mc/s_Q secondary standard obtained by multiplication contains 1 Mc/s sidebands and can, therefore, not be used for this purpose.

The voltages shown in the a-c voltage diagram (Fig. 28) are only approximate values that may differ with different settings of the 10 kc/s dial and also in different equipments.

The d-c voltage diagram (Fig. 29), too, contains only approximate values, which should be measured with an instrument of 50 k-ohms/volt.

The wiring diagram (Fig. 30) serves to facilitate the locating of circuit elements.

Calibrating instructions:

Oscillating circuit (Sp 12, C 60):

Turn switch S 3 to position "SEARCH," set dial to "100 × 10 kc/s" and adjust oscillator to 5.7 Mc/s by means of trimmer C 55.

Set dial to "0 × 10 kc/s" and adjust oscillator to 4.7 Mc/s by means of the core of coil Sp 12.

Taking turns, repeat the two processes several times.

Wide band transformer (Sp 13):

No means for realignment has been provided; should have its maximum at 5.2 Mc/s.

Tuned transformer (Sp 11, C 47):

Adjust to voltage maximum at 5 Mc/s by means of the core of the coil.

Tuned transformer (Sp 10, C 44):

Same as tuned transformer Sp 11, C 47.

Note:

For realigning purposes, the standard frequency 5 Mc/s can be used, which is obtained from the slide of the rheostat R 34.

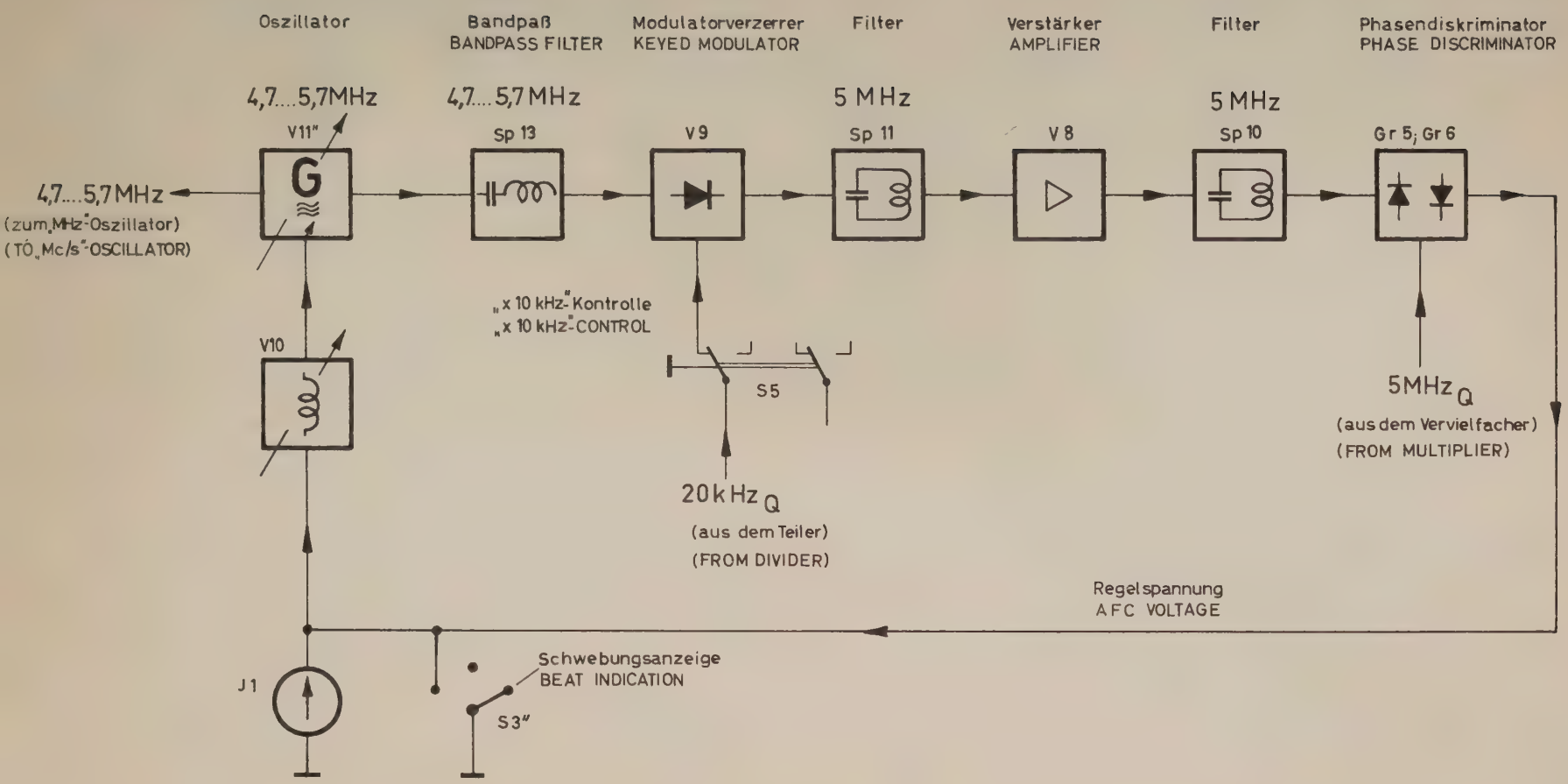


Bild 27 „x10kHz"-Oszillator (Blockschaltbild)
FIG. 27 „x10 kc/s"-OSCILLATOR (BLOCK DIAGRAM)

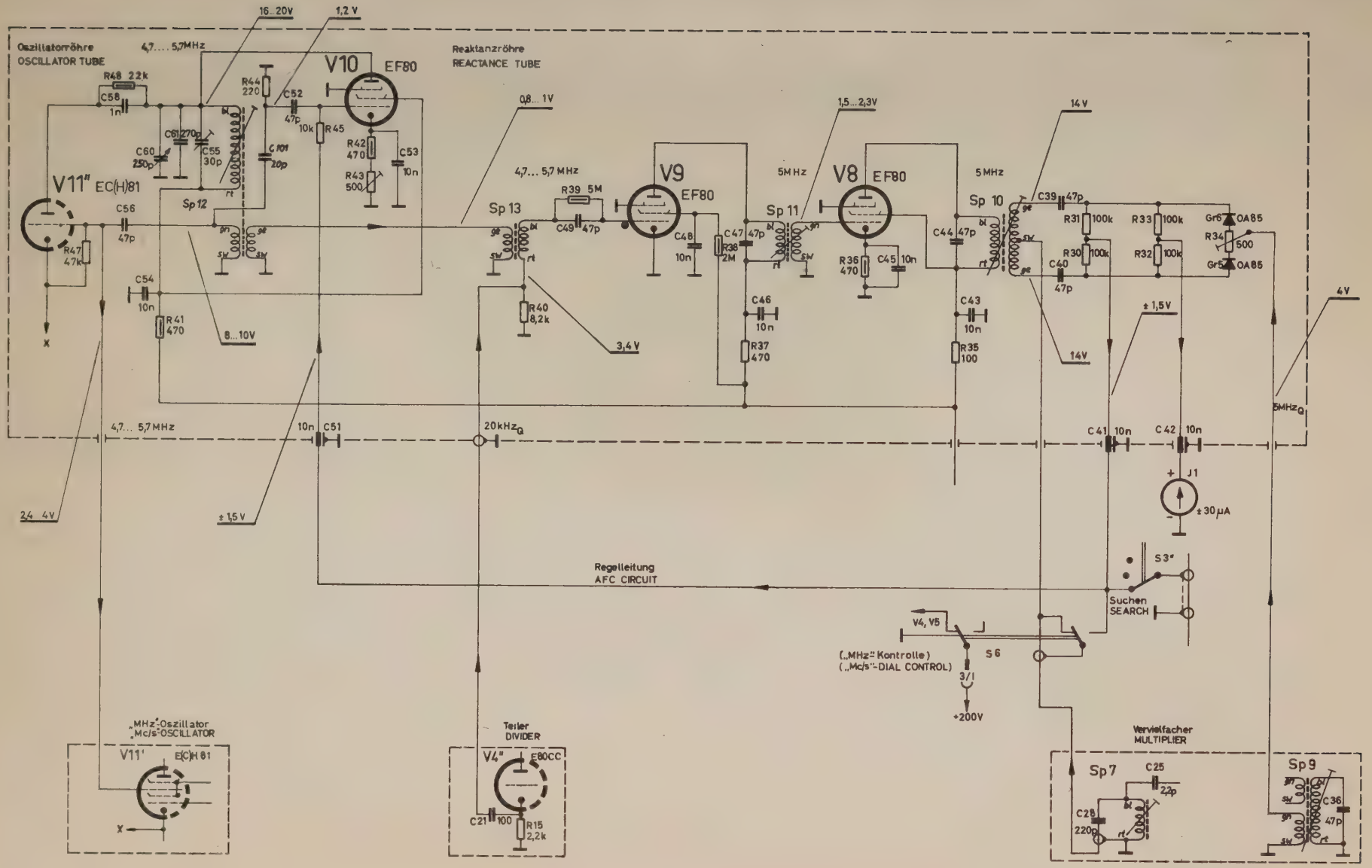


Bild 28 „x10kHz"-Oszillator (Wechselspannungen)
FIG. 28 „x10kc/s"-OSCILLATOR (A.C. VOLTAGES)

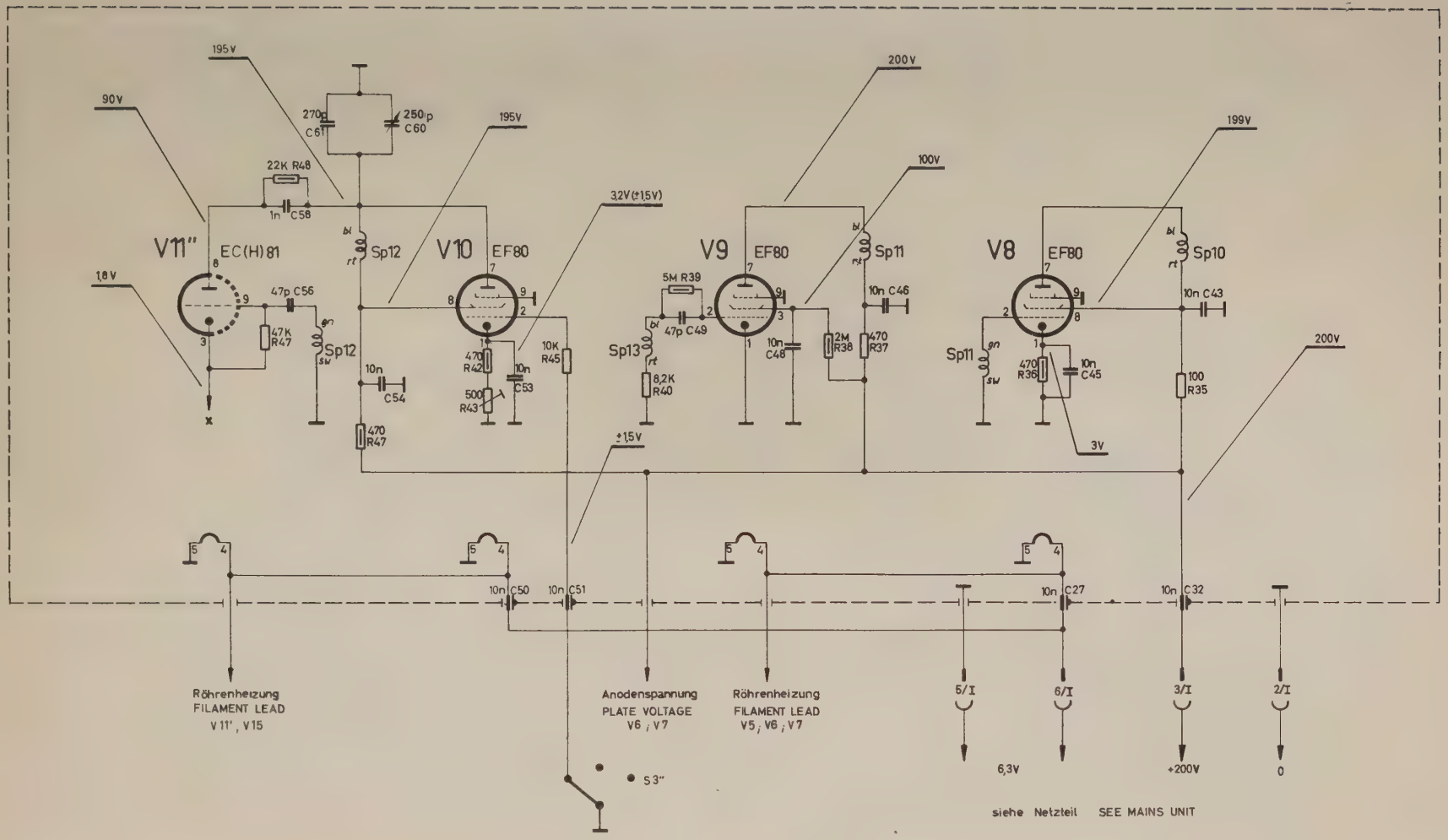


Bild 29 „x10kHz"-Oszillator (Gleichspannungen)
FIG. 29 „x10kc/s"-OSCILLATOR (D.C.VOLTAGES)

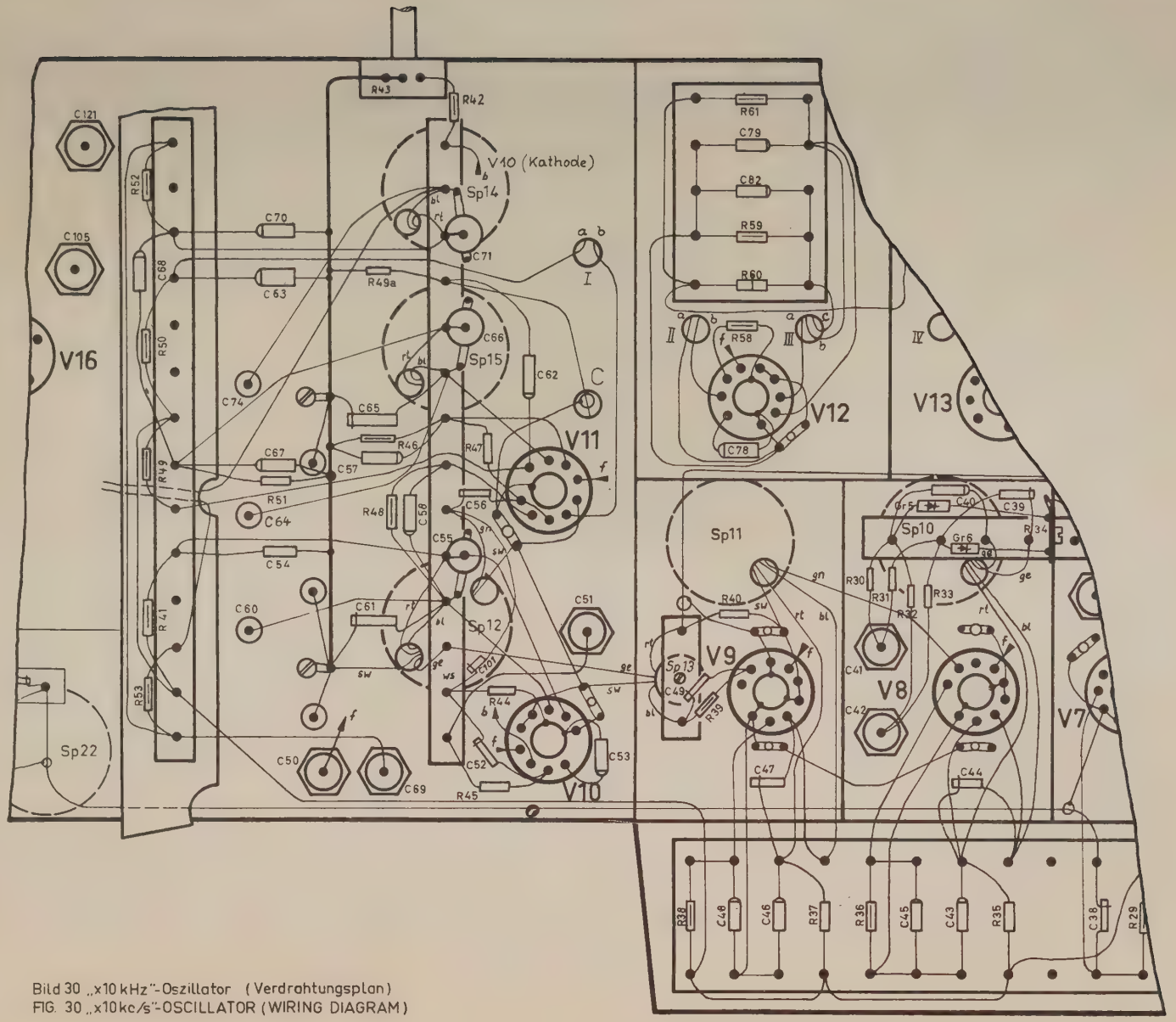


Bild 30 „x10 kHz"-Oszillator (Verdrahtungsplan)
FIG. 30 „x10 kc/s"-OSCILLATOR (WIRING DIAGRAM)

f) Low frequency amplifier

When conducting passive measurements, the LF amplifier serves to amplify the difference frequency between the frequency to be measured (f_x) and the reference frequency (f_v), i. e. the output frequency of the main oscillator, to obtain sufficient volume to drive a pair of headphones. Besides, the difference frequency can be displayed as a beat on the magic eye when it approaches zero beat, by turning switch S 3 to position "BEAT IND."

The operation of this stage will now be described by means of the a-c voltage diagram (Fig. 32) and the block diagram (Fig. 31).

The difefrence frequency is obtained from the "Mc/s" oscillator stage and conducted to the grid of the amplifier tube (V 19) by means of the multiple plug connection. In order to avoid hum loops, the cathode lead of this tube is conducted through the shielded lead and is grounded only in the mixer circuit ("Mc/s" oscillator).

The first amplifier is followed by a second one (V 20), from which the voltage is obtained at the plate and conducted to the headphones terminals via a voltage divider. At the same time, this voltage is conducted to switch S 3 via C 129, from where it is applied to the magic eye, when S 3 is in position "BEAT IND."

The voltages shown in the a-c voltage diagram (Fig. 32) are only approximate values which may differ in the individual equipment.

The same is applicable to the d-c voltage diagram (Fig. 33). These voltages should be measured with a 50 k-ohms/volt instrument.

The enclosed wiring diagram (Fig. 34) helps to avoid wearisome searching when locating circuit elements.

g) Power supply

The power supply unit for the Frequency Meter type FD 1, the 100 kc/s crystal oscillator, and the LF amplifier are mounted on one chassis, which may be removed from the equipment after unscrewing the four fixing screws. The connection to the equipment can then be reestablished by means of a "Tuchel" multiple plug connection.

There is nothing unusual about the power supply. It can be adjusted to different mains voltages by changing the solderings at the power transformer (see Fig. 34). Apart from the 200 V plate voltage supply, the power unit supplies a stabilised voltage of 150 V that is used only for the 100 kc/s oscillator.

Everything else may be seen from the circuit diagram (Fig. 35) and the wiring diagram (Fig. 34). Here, too, the indicated voltages are only approximate values to be used for comparative measurements.

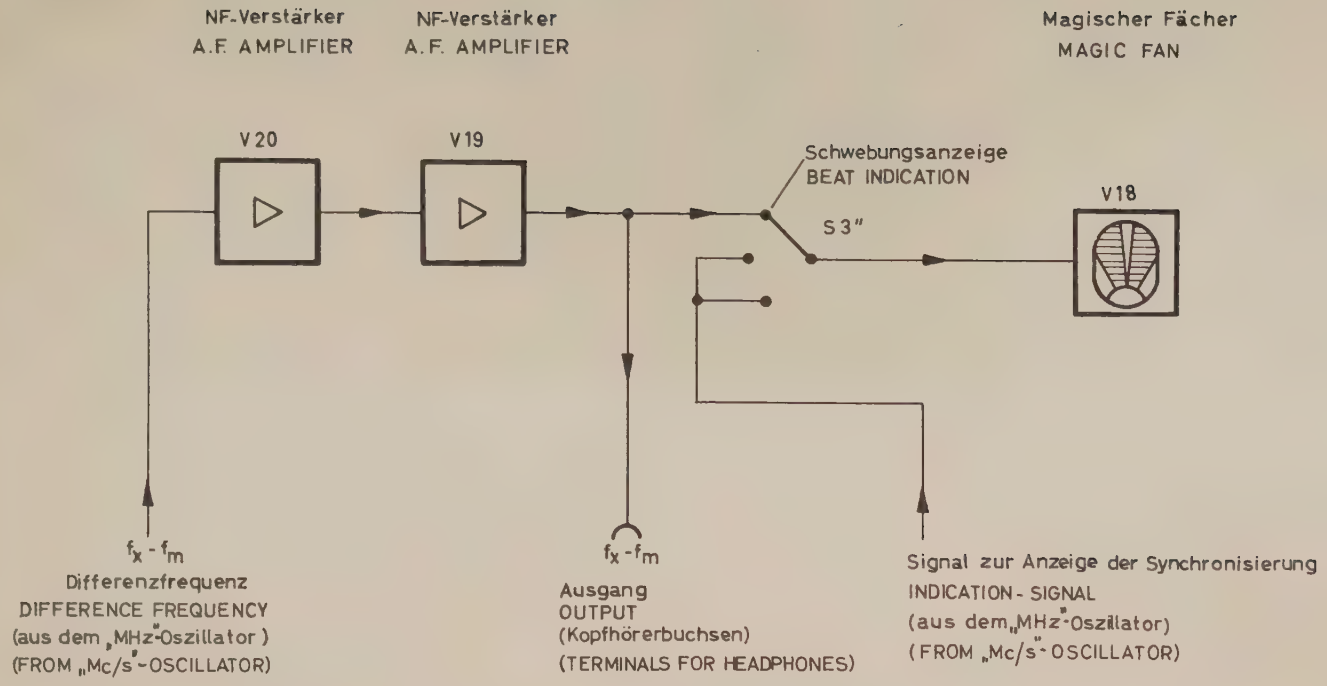


Bild 31 Niederfrequenzverstärker (Blockschaltbild)
FIG. 31 AUDIO FREQUENCY AMPLIFIER (BLOCK DIAGRAM)

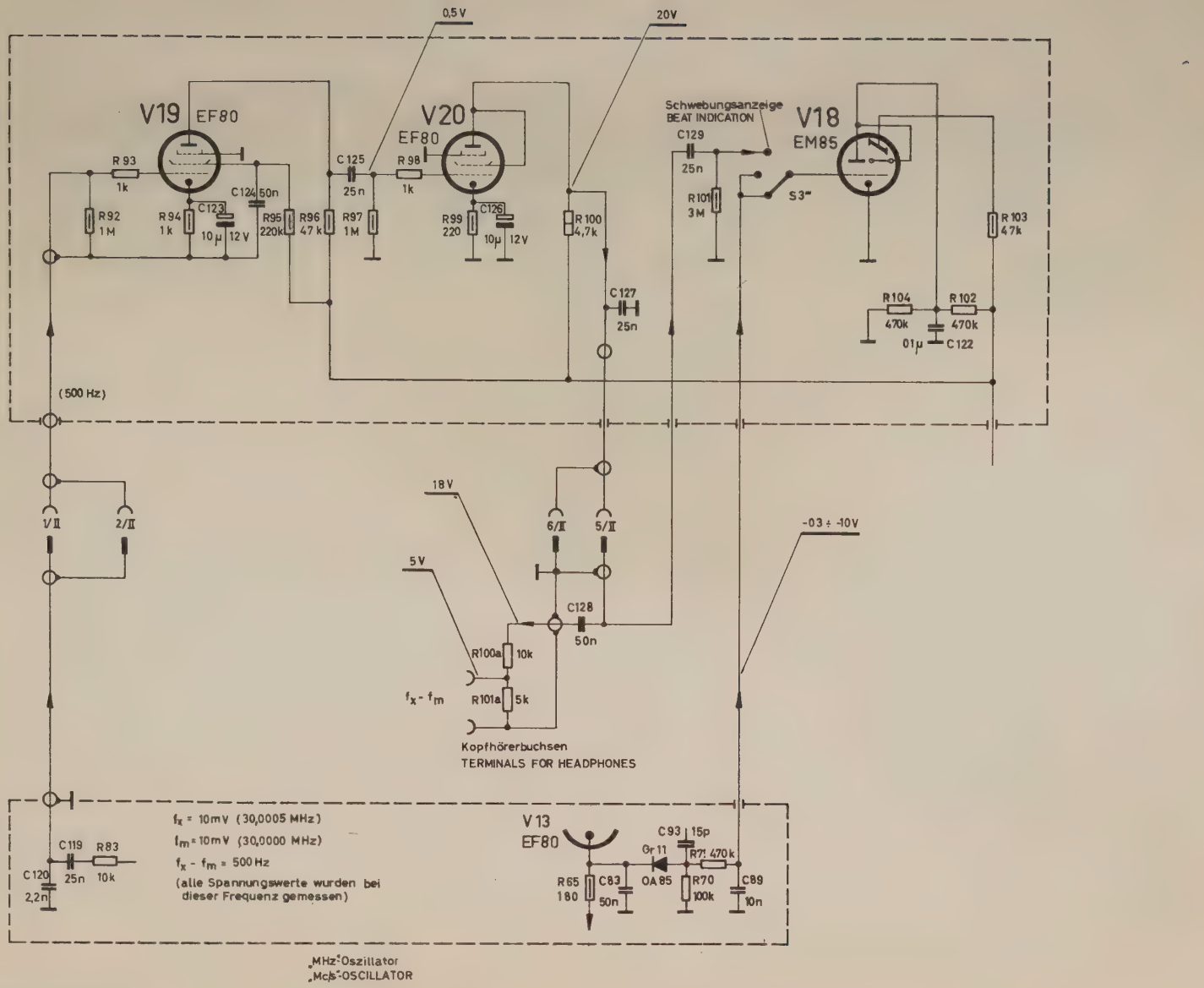


Bild 32 Niederfrequenzverstärker (Wechselspannungen)
FIG. 32 AUDIO FREQUENCY AMPLIFIER (A.C.VOLTAGES)

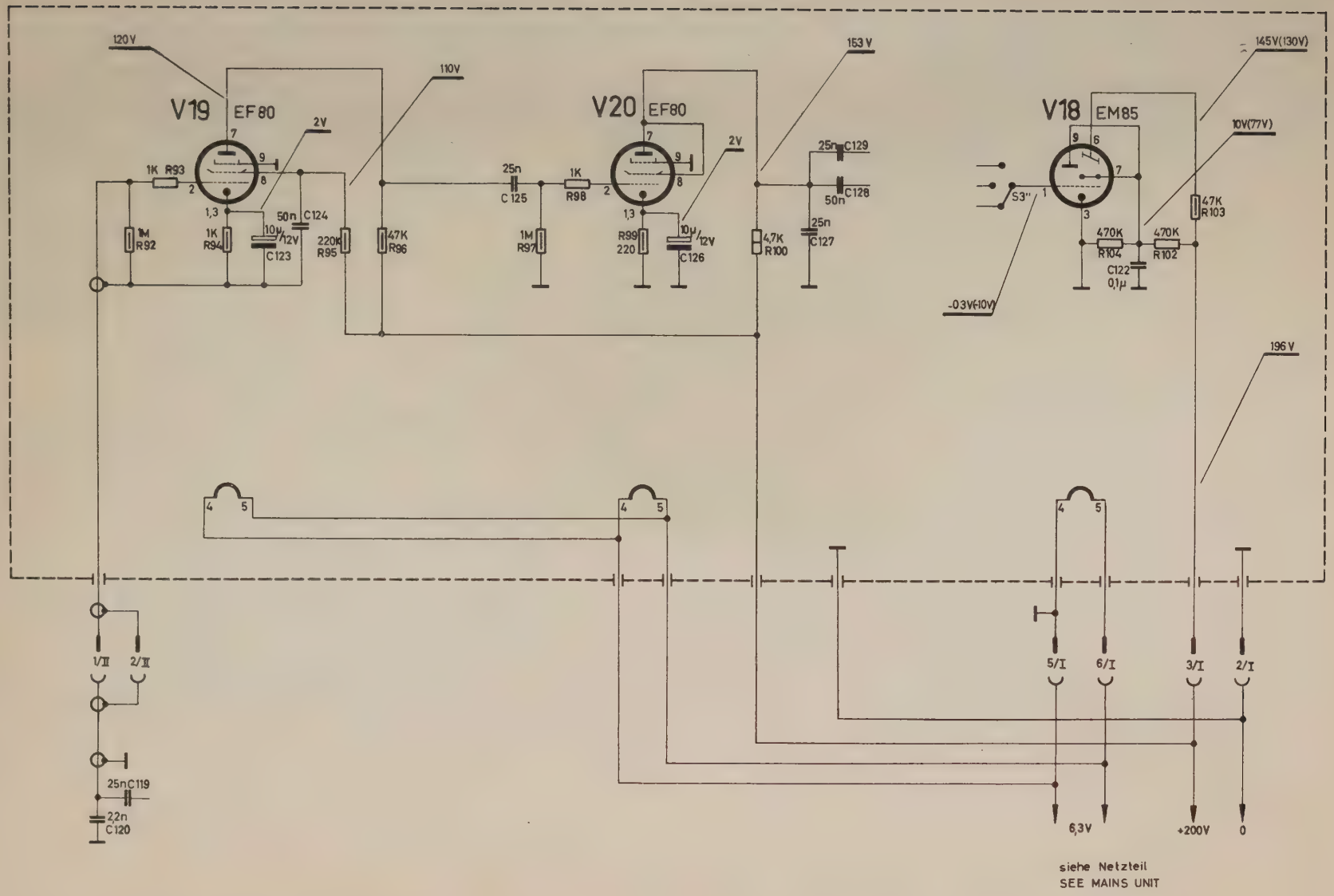


Bild 33 Niederfrequenzverstärker (Gleichspannungen)
FIG. 33 AUDIO FREQUENCY AMPLIFIER (D.C. VOLTAGES)

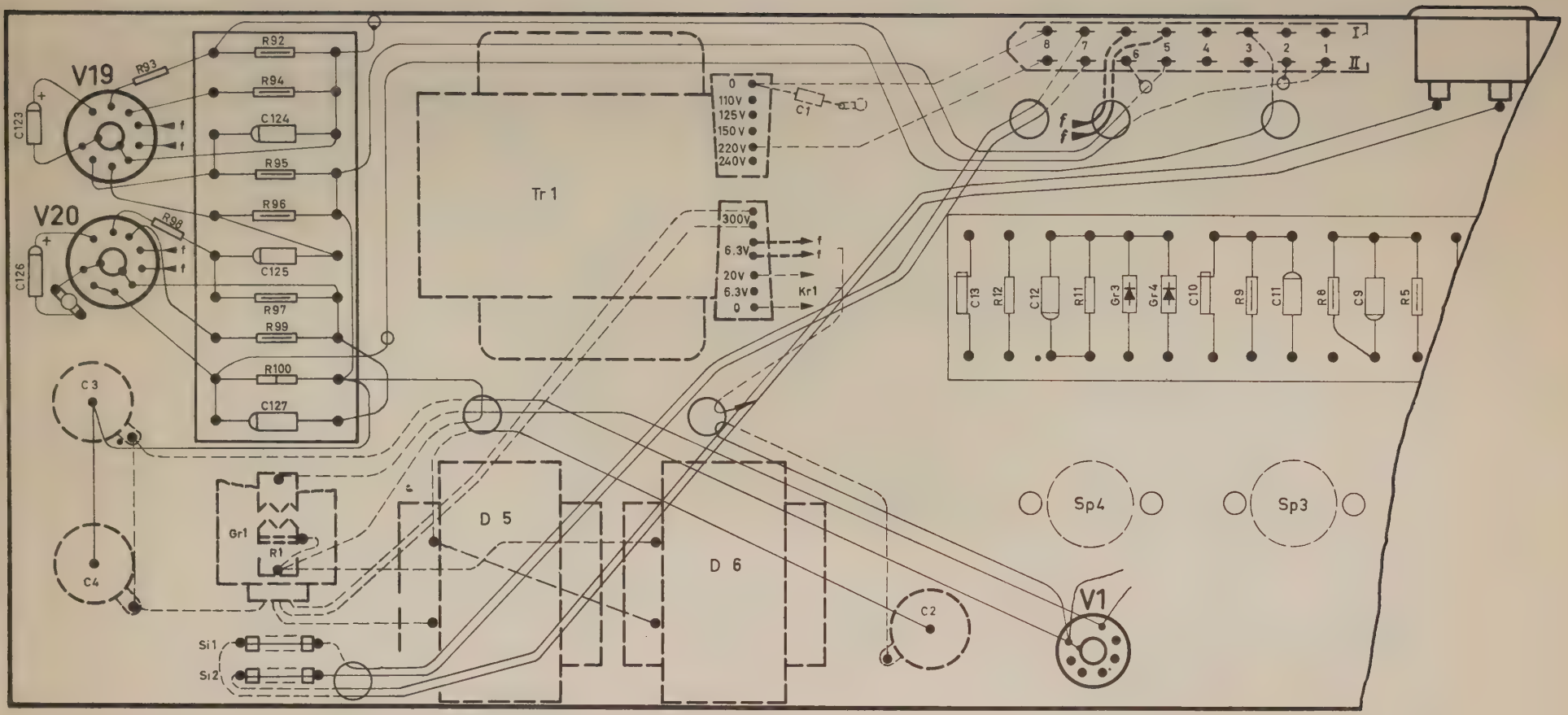


Bild 34 Niederfrequenzverstärker mit Netzteil (Verdrahtungsplan)
FIG. 34 AUDIO FREQUENCY AMPLIFIER WITH MAINS UNIT (WIRING DIAGRAM)

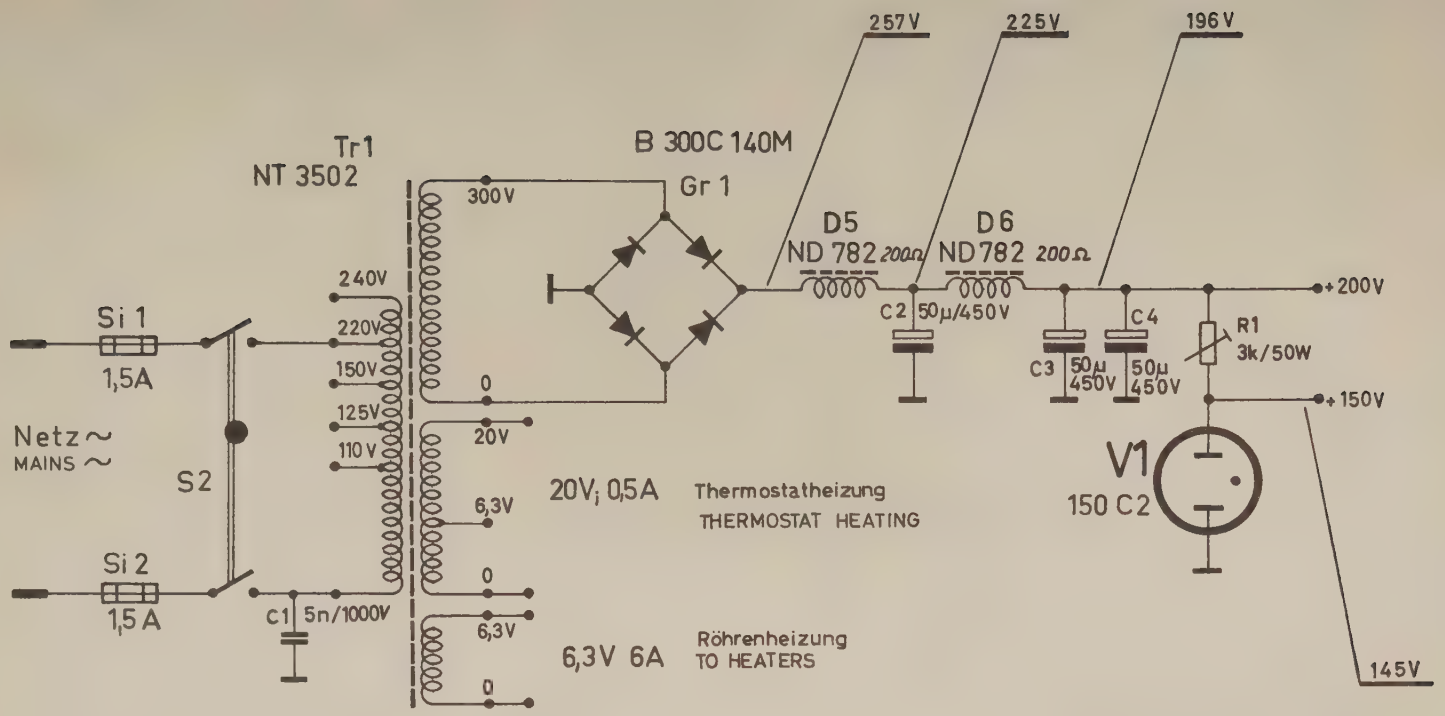


Bild 35 Netzteil
FIG. 35 MAINS UNIT

C. Servicing Instructions

A system has been worked out by which any defect occurring within the FD 1 can be located by means of the effect produced by such a defect on the indications of the front panel elements. For successful use of this system, the following has to be ascertained first:

1. That the power supply is in working condition and supplies the required voltages. (If doubted, measure voltages! Plate voltage 200 V, stabilised voltage 150 V, filament voltage 6.3 V).

2. Switch S 3 must be in position "MEASURE" and must be in good mechanical condition.

The front panel offers four possibilities of testing the equipment:

1. The magic eye (C. R. tuning indicator).

2. The meter located to the left of the Mc/s dial.

3. The meter located to the left of the 10 kc/s dial.

4. Output voltage at socket Bu 3 (approx. 10 mV, 30 to 90 Mc/s).

From these four possibilities of testing, a four-digit number is formed, which is used as a key number for trouble shooting.

The four digits should be determined in the following manner:

1st digit:

Magic eye:

The luminant angle of the magic eye (V 18) closes and opens at intervals of 1 Mc/s, when the Mc/s dial is varied throughout its range 0

The luminant angle does not change while the dial is varied throughout its range 3

2nd digit:

Meter located to the left side of the Mc/s dial:

a) Shows synchronisation deflections at intervals of 1 Mc/s when varying the Mc/s dial throughout its range 0

b) Shows deflections at intervals of 1 Mc/s when varying the dial, but does not synchronise properly (i.e. pointer rocks back and forth irregularly) 1

c) No deflection while the dial is varied throughout its range 3

3rd digit:

Meter located to the left of the 10 kc/s dial:

a) Shows synchronisation deflections at intervals of 20 kc/s, when the 10 kc/s dial is varied throughout its range 0

b) Shows deflections at intervals of 20 kc/s, when the 10 kc/s dial is varied throughout its range, but does not properly synchronise (displays beats) 1

c) Shows a synchronisation deflection only in position "30 × 10 kc/s" 2

d) Shows no deflection, when varying the 10 kc/s dial throughout its range 3

4th digit:

Output voltage available at output socket Bu 3 0

No output voltage available at output socket Bu 3 3

(Measure output voltage by means of adequate tube voltmeter; it should be approx. 10 mV, 30 to 90 Mc/s).

The four-digit number thus formed is looked up in the left column of the table. The circuit elements and leads involved in the failure are listed in the line behind that number. Then check the circuitry concerned, with the help of the corresponding chapter of the description in this manual.

Table of faults for the Service Frequency Meter type FD 1

Key number	Circuit involved	**) Observation	Page	Remark
3000 *)	**Low frequency amplifier:** V 18 ..... S 3‴ ..... (R 71).	**Magic eye:** Luminant angle does not close when varying dial throughout its range.	33	*) The circuitry from V 18 and J 2 to V 11′ can be tested as a whole by means of the test key "ZERO TEST". It should be possible, by varying the regulator "ZERO RESET", to put the pointer of the instrument J 2 to center Zero and to produce a maximum luminant sector on the magic eye.
	"Mc/s" oscillator: (S 3‴) ..... R 71 ..... Gr 11 ..... C 93 ..... R 69.]		27	
3300 *)	**"Mc/s" oscillator:** J 2 ..... R 55 (C 101) ..... R 68; R 67 .. .. V 14 ..... Sp 19 ..... V 13 ..... Sp 18 ..... V 12 ..... Sp 17 ..... Sp 16 ..... V 11′*) ..... Sp 15 ..... Sp 14 ..... V 15 ..... Sp 26; Sp 27; Sp 28 ..... R 74 ..... R 75 ..... Sp 23; Sp 24; Sp 25 ..... Gr 12 ..... C 99 ..... Sp 22 ..... concentric cable ..... (C 38)	**Instrument J 2** (beside Mc/s dial): No deflection when varying dial throughout its range.	27	**) The observations for key numbers 3000 thru 3333 are additive top to bottom.
	Multiplier: (concentric cable) ..... C 38 ..... V 7 ..... C 35 ..... Sp 8.]		23	
3330 (A)	**"10 kc/s" oscillator:** (V 11′) ..... V 11″ ..... Sp 12 ..... Sp 13.]	**Instrument J 1** (beside 10 kc/s dial): No deflection when varying dial throughout its range.	31	
3330 (B)	**"10 kc/s" oscillator:** (Gr 5; Gr 6) ..... R 34 ..... (Sp 9)		31	
	Multiplier: (R 34) ..... Sp 9 ..... Sp 8 ..... V 6 ..... Sp 7 ..... Sp 6 ..... V 5 ..... R 21 ..... concentric cable ..... (multiple plug connection 1/I)		23	
	100 kc/s crystal oscillator: (Multiple plug connection 1/I) ..... concentric cable ..... Sp 4 ..... Gr 3; Gr 4 ..... Sp 3 ..... V 3 ..... V 2 ..... Sp 1 ..... 100 kc/s crystal.]		21	
3333	**"Mc/s" oscillator:** (V 15) ..... Sp 29; Sp 30; Sp 31 ..... V 17.]	**Output socket (Bu 3):** No measurable output voltage (approx. 10 mV).	27	

Continued next page!

Table of faults for the Service Frequency Meter type FD 1 (contd.)

Key number	Circuit involved	Observation	Page	Remark
0003	**"Mc/s" oscillator:** (V 17) ..... C 117 ..... Gr 14 ..... C 118 ..... concentric cable ..... Bu 3.]	**Output socket (Bu 3):** No measurable output voltage (approx. 10 mV).	27	
0100	**"Mc/s" oscillator:** R 54 ..... C 106 ..... C 105 ..... C 107 ..... R 77 ..... V 16.]	**Instrument J 2** (beside Mc/s dial): Shows deflections at intervals of 1 Mc/s, but oscillator does not synchronise (heavy, irregular rocking of pointer).	27	
0030	**"10 kc/s" oscillator:** J 1 ..... C 42 ..... R 32; R 33 ..... Gr 5; Gr 6 ..... Sp 10 ..... V 8 ..... Sp 11 ..... V 9 ..... Sp 13.]	**Instrument J 1** (beside 10 kc/s dial): No deflections when varying dial throughout its range.	31	
0010	**"10 kc/s" oscillator:** R 30; R 31 ..... C 41 ..... C 51 ..... R 45 ..... V 10.]	**Instrument J 1** (beside 10 kc/s dial): When varying dial throughout its range, deflections occur at intervals of 20 kc/s, but oscillator does not synchronise, (pointer shows beat).	31	
0020	**"10 kc/s" oscillator:** R 40 ..... concentric cable ..... (C 21) **Divider:** (concentric cable) ..... C 21 ..... V 4 ..... Sp 5; C 20.]	**Instrument J 1** (beside 10 kc/s dial): When varying dial throughout its range, a synchronisation deflection occurs only in dial position "30 × 10 kc/s."	31 25	

Detailed realigning instructions for the Service Frequency Meter type FD 1

If the Frequency Meter type FD 1 is to be completely realigned, this is preferably done in the order given below. If a realignment in accordance with these instructions is not possible, potential faults can also be found by measuring the voltages of the circuit in which the element to be realigned is located, and comparing them with the values given on the voltage diagrams.

Sp 1 (Fig. 12)	Disconnect the crystal diode Gr 2 on one side, remove crystal oven with crystal from its support, and connect cathode of V 2 to the ground via a 470-ohms resistor.
(Fig. 9)	Connect oscilloscope to 100 kc/s test point. Compare to external 100 kc/s standard of an accuracy as high as possible, (crystal-controlled if possible), and adjust core of coil Sp 1 in such a way that a slowly turning 1 : 1 Lissajous figure is displayed. Fasten core with wax. Remove 470-ohms resistor, replace oven in its support, and solder diode Gr 2 to its connection again.
C 15 (Fig. 12)	Set trimmer C 14 to center position. After heating the oven for one hour, adjust series capacitor C 15 in such a way that the 1 : 1 Lissajous figure on the oscilloscope screen comes to standstill.
Sp 3 (Fig. 12)	Oscilloscope is left as before. Then adjust core of the coil in such a way that the 100 kc/s frequency has maximum amplitude. Fix core in place with wax.
Sp 4 (Fig. 12)	Connect one pair of the deflection plates of the oscilloscope to the 200 kc/s test point. Adjust core of coil Sp 4 to maximum amplitude at 200 kc/s.
Sp 5 (Figs. 9, 20)	Connect one pair of plates of the oscilloscope to the 100 kc/s test point, the other one to the 20 kc/s test point. Disconnect one terminal of capacitor C 19. Then adjust coil Sp 5 in such a way that a slowly turning 5 : 1 Lissajous figure is displayed. Fasten core with wax. Solder capacitor terminal back into place. Note: Before realigning coils Sp 6, 7, 8, 9, 10, 11, 12, 14, 15, 22, they should be brought into their approximately correct positions, i. e. the cores should be flush with the ends of the coil formers.
Sp 6 (Fig. 16)	Connect tube voltmeter to blue terminal of Sp 6 via a 1 pF capacitor. Adjust core of coil so that the voltmeter displays maximum deflection at 1 Mc/s.
Sp 7 (Fig. 16)	Adjust in the same manner as coil Sp 6.
Sp 8 (Fig. 16)	Connect tube voltmeter to yellow terminal of the coil. Then adjust core of coil so that a maximum deflection is achieved at 5 Mc/s. At the same time, adjust coils Sp 6 and Sp 7.
Sp 9 (Fig. 16)	Connect tube voltmeter to green terminal of coil Sp 9. Adjust core of this coil to maximum deflection at 5 Mc/s. Now readjust coils Sp 6, Sp 7, Sp 8, Sp 9 once more and fasten cores with wax.
Sp 11 (Fig. 28)	Connect green terminal of Sp 9 to blue terminal of Sp 13 by a piece of wire. (By this means, the 5 Mc/s frequency is put across the control grid of tube V 9.) Connect tube voltmeter to green terminal of coil Sp 11. Then adjust core of coil Sp 11 to maximum deflection at 5 Mc/s.
Sp 10 (Fig. 28)	Connect tube voltmeter to yellow terminal of coil Sp 10 and adjust core to maximum deflection at 5 Mc/s. At the same time realign Sp 11 once more. Fix cores in place. Remove wire connection between Sp 9 and Sp 13.
Sp 12; C 55 (Fig. 28)	Set functional switch to position "MEASURE." Then the push button "TEST" beside the 10 kc/s dial should be pressed. In position "30 × 10 kc/s" of the 10 kc/s dial, a synchronisation deflection will be displayed on the instrument J 1. Now check all the 20 kc/s points of the 10 kc/s dial. If the dial is out of tune, adjust zero point of dial by means of the core of coil Sp 12, and adjust dial point "100 × 10 kc/s" by means of the trimmer C 55. Repeat the two operations several times, taking turns. Then fasten core with wax, fix trimmer with lacquer.
Sp 16 (Fig. 24b)	Apply a frequency of 310 kc/s obtained from a signal generator, to the control grid of tube V 11.
Sp 17 (Fig. 24b)	Connect tube voltmeter to green terminal of coil Sp 17. Adjust trimmers C 75 and C 77 so that the tube voltmeter displays maximum deflection at 310 kc/s.

Sp 18 (Fig. 24b)

Connect tube voltmeter to yellow terminal of coil Sp 19. Reduce output voltage of signal generator to such a degree that the limiter diodes are not yet effective, so that the maximum deflection displayed on the tube voltmeter is unequivocal. Adjust by means of trimmers C 75, C 77, C 80, and fix trimmers with lacquer.

Sp 19 (Fig. 24b)

Set signal generator to 300 kc/s. Adjust trimmer C 84 so that the tube voltmeter shows maximum deflection at 300 kc/s. Note that the output voltage of the signal generator should be kept low enough to prevent the limiter diodes from becoming effective.

Sp 21 (Fig. 24b)

Adjust coil Sp 21 to a middle position.

Sp 20 (Fig. 24b)

Adjust core of coil Sp 20 so that the luminant angle displayed on the magic eye has its maximum at 300 kc/s (Switch in position "MEASURE"). The fine adjustment of this coil with C 86 with regard to the dial calibration is described later.

Sp 15 (Fig. 24a)

The 5 Mc/s frequency is connected from the green terminal of coil Sp 9 to the blue terminal of coil Sp 15 via a capacitor of approx. 10 pF. The functional switch should be in position "MEASURE" and the 10 kc/s dial in position "0 × 10 kc/s." Now remove tubes V 15 and V 17 from their sockets. Adjust core of coil Sp 15 to maximum luminant angle on the magic eye. In order to be able to adjust to a sharp maximum, it is recommended to place a damping resistor between the green terminal of coil Sp 17 and the ground, or to measure the maximum indication at this point by means of a tube voltmeter.

Sp 14 (Fig. 24a)

Plug tube V 15 back in. The 5 Mc/s frequency applied to the blue terminal of Sp 15 via 10 pF is now put across the control grid of tube V 15. Then adjust by means of the core of coil Sp 14 in the same manner as described under Sp 15. Also, realign Sp 15 once more. The adjustment of coils Sp 14 and Sp 15 as described here need only be a coarse one, which can be performed without the help of any measuring gear. The fine alignment will be described later.

Sp 22 (Fig. 24a)

Unsolder one terminal of the coupling capacitor C 35. A frequency of 20 Mc/s obtained from a signal generator is put across the control grid of tube V 7. Unsolder the ground connection of the resistor R 75 and reconnect via a 100 μA ammeter. Then adjust the core of coil Sp 22 to maximum deflection on the instrument. Restore normal conditions.

Sp 29 (Fig. 24a)
Sp 30 (Fig. 24a)
Sp 31 (Fig. 24a)

Plug tube V 17 back into its socket. A signal generator (range: 30 to 90 Mc/s) is connected to the output socket (Bu 3) of the FD 1. Now test the calibration of the "Mc/s" oscillator against the signal generator. In range 3, adjust the frequency at the upper end of the dial (90 Mc/s) to that of the signal generator by means of trimmer C 113, at the lower end (60 Mc/s) by means of coil Sp 31. Repeat the two operations several times, taking turns. Then perform adjustment in the same manner in range 2: at 61 Mc/s by means of C 130, at 43 Mc/s by means of Sp 30, and in range 1: at 43 Mc/s by means of C 131 and at 30 Mc/s by means of Sp 29.

When the frequency of the "Mc/s" oscillator corresponds roughly to the dial calibration, the ganged filter (Sp 23 to Sp 28) can be aligned. It has to be so adjusted that it has a passband of 1 Mc/s. That means: the resonance frequency of the resonant circuit C 97, Sp 23 to Sp 25, is exactly 5 Mc/s below that of the "Mc/s" oscillator, the resonance frequency of the resonant circuit C 95; Sp 26 to Sp 28, is 6 Mc/s below the oscillator frequency.

Sp 23 (Fig. 24a)
Sp 24 (Fig. 24a)
Sp 25 (Fig. 24a)

The 10 kc/s dial is set to "0" again, the fine tuning dial is set to "0 + 10 kc/s," and the Mc/s dial is set to 90 Mc/s (range 3). Now adjust trimmer C 98 so that the magic fan shows a maximum luminant angle at 85 Mc/s. (In order to obtain an unequivocal maximum, the limiters must remain ineffective; therefore, a damping resistor should be inserted between the green terminal of coil Sp 17 and the ground!). Adjust coil Sp 25 in the same manner to maximum voltage at 57 Mc/s, with the dial in position 62 Mc/s. The alignment of C 98 and Sp 25 should be repeated several times, taking turns.

Range 2 is adjusted in the same manner: trimmer C 140 to 56 Mc/s in dial position 61 Mc/s, coil Sp 24 to 38 Mc/s in dial position 43 Mc/s.

Range 1 accordingly: trimmer C 139 to 38 Mc/s in dial position 43 Mc/s and coil Sp 23 to 25 Mc/s in dial position 30 Mc/s.

Note:

The second ganged circuit C 95; Sp 26 to Sp 28 should be roughly adjusted and its resonant frequency should be in the vicinity of that of the above mentioned circuit C 97; Sp 23 to Sp 25. The alignment of the circuit C 95; Sp 26 to Sp 28, is done after the fine adjustment of the ganged filter C 74, Sp 14, and C 64, Sp 15.

Sp 14 (Fig. 24a)
Sp. 15 (Fig. 24a)

The "Mc/s" oscillator should be synchronised to a Mc/s point. Set 10 kc/s dial to "0" and fine tuning dial to "0 + 10 kc/s." Now adjust coils Sp 14 and Sp 15 to maximum

indication on magic eye, the same is done with trimmers C 71 and C 66 in position "100 × 10 kc/s" of the 10 kc/s dial. This operation is repeated several times. Now the second ganged circuit (C 95, Sp 26 to Sp 28) of the "Mc/s" oscillator can be adjusted.

Sp 26 (Fig. 24a)
Sp 27 (Fig. 24a)
Sp 28 (Fig. 24a)

The "10 kc/s" oscillator should be in position "100 × 10 kc/s" and the fine tuning dial in position "0 + 10 kc/s." Set Mc/s dial to 90 Mc/s in range 3. Now align trimmer C 94 to 84 Mc/s in such a way that the magic eye displays a maximum indication.

(In order to obtain a sharp maximum, the limiters must remain ineffective. For this purpose, an attenuating resistor should be connected between the green terminal of coil Sp 17 and the ground.)

Coil Sp 28 is adjusted to 56 Mc/s in dial position 62 Mc/s, in the same manner. This two-point adjustment C 94, Sp 28, is repeated several times.

For the alignment of range 2, the same method is used: adjust to 55 Mc/s in dial position 61 Mc/s by means of trimmer C 137 and to 37 Mc/s in dial position 43 Mc/s by means of coil Sp 27. In range 1 adjust to 37 Mc/s in dial position 43 Mc/s by means of C 138 and to 24 Mc/s in dial position 30 Mc/s by means of coil Sp 23.

The alignment of the ganged circuits is repeated once more. Now, the magic eye must show maximum indications for all dial positions of the Mc/s and 10 kc/s dials, after the damping resistor has been removed. Also, the pointer of instrument J 2 follows the dial movement within each of the hold-in ranges of the Mc/s synchronisation points.

R 69 (Fig. 24b)

The pointer is adjusted to center zero and a defined ± variation (say ± 20 kc/s) is adjusted by means of the 10 kc/s dial. If the ± indication on the instrument is not symmetrical, it can be balanced by means of the variable resistor R 69.

Finally, the fine tuning dial is adjusted:

Sp 20 (Fig. 24b)

Set dial to "0". When the key S 4 (ZERO TEST) is pressed now, the luminant sector of the magic eye closes. Now adjust core of coil Sp 20 in such a way that the pointer of the instrument J 2 is exactly on center zero. (Sp 21 must remain in center position!). To crosscheck, the above can also be done in the following manner:

Set fine tuning dial to "0," synchronise 10 kc/s dial to "2 × 10 kc/s," and synchronise Mc/s dial to any Mc/s point, so that the pointer of instrument J 2 is exactly on center zero. Now set fine tuning dial to 20 kc/s.

As a result, the pointer of instrument J 2 has been pulled to the right. When the 10 kc/s dial is now put back to "0," the pointer must be back again exactly on center zero. If there is a deviation, it can be corrected by means of trimmer C 88 at "20 kc/s" and by means of Sp 20 at "0."

Note:

After the realignment has been completed, all loosened coils and trimmers have to be fixed again by means of wax or lacquer, respectively.

D. Some details on the mechanical structure of the Model FD 1

a) How to remove the bonnet:

The bonnet has been fastened by four screws accessible on the back of the equipment. After loosening them by means of a screw driver, the bonnet can be taken off.

b) How to remove the dial knobs:

The dial knobs are a Philips product. They are removed in the following manner:
In the center of the knob there is a circular cover plate that can be lifted at the edge by means of a screw driver, and removed to reveal a slotted hexagonal head screw. After loosening this screw, the knob can easily be pulled off. (It is similarly designed as a drill socket.)

c) How to remove the power supply and crystal unit:

The two chassis of the equipment have been so arranged that they are fastened bottom to bottom. When repairs have to be made on any of the two chassis, the one holding the power supply and the crystal oscillator can be removed in the following manner:

Unplug multiple knife plug and loosen the fastening screws of this chassis. Now pull chassis out to the side. After connecting the multiple plug again, the equipment is serviceable while the bottom sides of both chassis are accessible.

E.

Parts list for FD 1

Code	Designation	El. values, Ordering ref., Manufacturer
C 1	Rolled paper capacitor	5000 pF/1000 V d Th 250/10 (EROTROP) ERO
C 2	Electrolytic capacitor	50 µF 450/550 V Siemens 50/450/B 4 309
C 3	see C 2	
C 4	see C 2	
C 5	Rolled paper capacitor	0,05 µF/250 V d Tm 350/2 d (EROTROP) ERO
C 6	Tubular capacitor	Rk 330 pF/±2%/500 V Rd 4×25 D 90 Stettner
C 7	Rolled paper capacitor	0,025 µF/250 V d Tm 325/2 d (EROTROP) ERO
C 8	Tubular capacitor	Rk 10 pF/±0,5 pF/500 V Rd 2×12 D 20 Stettner
C 9	see C 5	
C 10	Tubular capacitor	Rk 390 pF/±2%/500 V Rd 8×50 D 20 Stettner
C 11	see C 5	
C 12	see C 7	
C 13	see C 10	
C 14	Air dielectric trimmer	100 pF 82076/100 E VALVO
C 15	Tubular capacitor	100 .... 500 pF adjust
C 16	see C 5	
C 17	see C 7	
C 18	see C 7	
C 19	Tubular capacitor	Rk 33 pF/±2%/500 V Rd 3×20 D 20 Stettner
C 20	Polysterene capacitor	1000 pF/250 V/20% F 1000/20/250 B 3101 Siemens
C 21	Tubular capacitor	Rk 100 pF/±2%/500 V Rd 4×30 D 20 Stettner
C 22	see C 7	
C 23	Tubular capacitor	Rk 220 pF/±2%/500 V Rd 8×40 D 20 Stettner
C 24	see C 7	
C 25	Disc capacitor	Sk 2,2 pF/±0,5 pF/500 V Sb D 20 Stettner
C 26	Bushing capacitor	0,01 µF/500 V Tf 310/5 ERO
C 27	see C 26	
C 28	see C 23	
C 29	see C 21	
C 30	Polysterene capacitor	10000 pF/250 V/20% F 10000/20/250 B 3101 Siemens
C 31	Tubular capacitor	Rk 47 pF/±2%/500 V Rd 4×20 D 20 Stettner
C 32	see C 26	
C 33	see C 20	
C 34	see C 21	
C 35	see C 31	
C 36	see C 31	
C 37	see C 30	
C 38	see C 31	
C 39	see C 31	
C 40	see C 31	
C 41	see C 26	
C 42	see C 26	
C 43	see C 30	
C 44	see C 31	
C 45	see C 30	
C 46	see C 30	
C 47	see C 31	
C 48	see C 30	
C 49	see C 31	
C 50	see C 26	
C 51	see C 26	
C 52	see C 31	
C 53	see C 30	
C 54	see C 30	
C 55	Air dielectric trimmer	3 .... 30 pF 7864/01 VALVO
C 56	see C 31	
C 57	see C 30	
C 58	see C 20	

Parts list for FD 1

Code	Designation	El. values, Ordering ref., Manufacturer
C 59		
C 60	3-ganged air dielectric variable capacitor	3×160 pF C 001 DA/3×160 E VALVO
(C 64)		
(C 74)		
C 61	Tubular capacitor	Rk 270 pF/±2%/500 V Rd 8×50 D 20 Stettner
C 62	see C 30	
C 63	see C 7	
C 64	see C 60	
C 65	see C 6	
C 66	see C 55	
C 67	see C 30	
C 68	see C 7	
C 69	see C 26	
C 70	see C 30	
C 71	see C 55	
C 72	see C 6	
C 73	see C 30	
C 74	see C 60	
C 75	see C 55	
C 76	Tubular capacitor	Rk 6,8 pF/±0,5 pF/500 V Sb D 20 Stettner
C 77	see C 55	
C 78	see C 5	
C 79	see C 7	
C 80	see C 55	
C 81	see C 7	
C 82	see C 5	
C 83	see C 5	
C 84	see C 55	
C 85	see C 8	
C 86	Air dielectric variable capacitor	250 pF C 001 AA/250 E VALVO
C 87	see C 6 2 pieces see C 10 2 pieces	
C 88	see C 14	
C 89	see C 30	
C 90	see C 7	
C 91	see C 30	
C 92	see C 30	
C 93	Tubular capacitor	Rk 15 pF/±0,5 pF/500 V Rd 3×12 D 20 Stettner
C 94	see C 55	
C 95	3-ganged air dielectric variable capacitor	3×40 pF C 001 EA/3×40 E VALVO
(C 97)		
(C 114)		
C 96	Disc capacitor	Sk 2200 pF/500 V Sa D 3000 Stettner
C 97	see C 95	
C 98	see C 55	
C 99	see C 31	
C 100	see C 96	
C 101	Tubular capacitor	Rk 20 pF/±0,5 pF/500 V Rd 3×12 D 20 Stettner
C 102	see C 96	
C 103	Electrolytic capacitor	10 μF 12/15 V 10/12 B 4117 Siemens
C 104	see C 96	
C 105	see C 26	
C 106	Can paper capacitor	0,5 μF/250 V Dk 450/2 Form B ERO
C 107	see C 96	
C 108	see C 26	
C 109	Tubular capacitor	Rk 150 pF/±2%/500 V Rd 4×40 D 20 Stettner
C 110	see C 31	
C 111	see C 8	

Parts list for FD 1

Code	Designation	El. values, Ordering ref., Manufacturer
C 112	Tubular capacitor	Rk 22 pF/±0,5 pF/500 V Rd 3×16 D 20 Stettner
C 113	see C 55	
C 114	see C 95	
C 114a	see C 6	
C 115	see C 96	
C 116	see C 96	
C 117	see C 96	
C 118	see C 96	
C 119	see C 7	
C 120	see C 96	
C 121	see C 26	
C 122	Rolled paper capacitor	0,1 μF/250 V d Th 410/2 d ERO
C 123	see C 103	
C 124	see C 5	
C 125	see C 7	
C 126	see C 103	
C 127	see C 7	
C 128	see C 5	
C 129	see C 7	
C 130	Tubular trimmer	4 pF 82025/4 E VALVO
C 131	see C 130	
C 132	Miniature ceramic capacitor	PK 0,6 pF 5×6 D 6 Stettner
C 133	Tubular capacitor	RK 68 pF/10%/500 V Rd 4×25 D 20 Stettner
C 134	Tubular capacitor	RK 10 pF/10%/500 V Rd 3×12 D 20 Stettner
C 135	Tubular capacitor	RK 47 pF/10%/500 V Rd 4×20 D 20 Stettner
C 136	see C 134	
C 137	see C 130	
C 138	see C 130	
C 139	see C 130	
C 140	see C 130	
C 141	see C 134	
D 1	Choke	approx. 4 μH FD 1 Bv-22 Schomandl
D 2	Choke	approx. 2 μH FD 1 Bv-22 Schomandl
D 3	Choke	approx. 1 μH FD 1 Bv-22 Schomandl
D 4	Choke	approx. 6 μH FD 1 Bv-22 Schomandl
D 5	Smoothing choke	200 Ohm; 100 m A 0333 Schumacher
D 6	Smoothing choke	200 Ohm; 100 m A 0333 Schumacher
D 7	Choke	60 turns FD 1 Bv-23 Schomandl
D 8	Choke	60 turns FD 1 Bv-23 Schomandl
Gr 1	Rectifier	300 V; 150 mA B 300 C 150 M AEG
Gr 2, Gr 11	Crystal diode	OA 85 VALVO
Gr 12	Crystal diode	OA 73 VALVO
Gr 13	see Gr 2	
Gr 14	see Gr 12	
J 1	Moving coil instrument	±30 μA 2000 Ohm Bv.: FD 1 - J 1 scale 1 Neuberger
J 2	see J 1	
Kr 1	100 kc/s control crystal with oven	20 V; 0,5 A; 50° C Rel ther 3 a Bv 673/S 33 Siemens
La 1	Signal lamp	18 V/0,1 A E 10 Osram
R 1	Wire-wound resistor	3 kOhm/50 W w. slider clamp Neawid Pressler
R 2	Layer resistor	1 kOhm; 0,5 W; ±5% SWD 0,5 KI 2 Rosenthal
R 3	Layer resistor	180 Ohm; 0,5 W; ±5% SWD 0,5 KI 2 Rosenthal
R 4	Layer resistor	100 kOhm; 0,5 W; ±5% SWD 0,5 KI 2 Rosenthal
R 5	Layer resistor	1 MOhm; 0,5 W; ±5% SWD 0,5 KI 2 Rosenthal
R 6	Layer resistor	180 Ohm; 0,5 W; ±5% SWD 0,5 KI 2 Rosenthal
R 7	Layer resistor	220 Ohm; 1 W; ±5% SWD 1 KI 2 Rosenthal
R 8	Layer resistor	220 Ohm; 0,5 W; ±5% SWD 0,5 KI 2 Rosenthal

Parts list for FDM 1

Code	Designation	El. values, Ordering ref., Manufacturer
R 9	see R 2	
R 10	Layer resistor	10 kOhm; 0,25 W; 5% SWD 0,25 Kl 2 Rosenthal
R 11	Layer resistor	820 Ohm; 0,25 W; ±5% SWD 0,25 Kl 2 Rosenthal
R 12	Layer resistor	47 kOhm; 0,25 W; ±5% SWD 0,25 Kl 2 Rosenthal
R 13	see R 12	
R 14	Layer resistor	100 kOhm; 0,25 W; ±5% SWD 0,25 Kl 2 Rosenthal
R 15	Layer resistor	2,2 kOhm; 0,5 W; ±5% SWD 0,5 Kl 2 Rosenthal
R 16	Layer resistor	15 kOhm; 0,25 W; ±5% SWD 0,25 Kl 2 Rosenthal
R 17	Layer resistor	10 kOhm; 1 W; ±5% SWD 1 Kl 2 Rosenthal
R 18	see R 17	
R 19	Layer resistor	470 Ohm; 0,5 W; ±5% SWD 0,5 Kl 2 Rosenthal
R 20		
R 21	Layer resistor	12 kOhm; 0,25 W; ±5% SWD 0,25 Kl 2 Rosenthal
R 22	see R 4	
R 23	Layer resistor	10 kOhm; 0,5 W; 5% SWD 0,5 Kl 2 Rosenthal
R 24	Layer resistor	5 MOhm; 0,5 W; 5% SWD 0,5 Kl 2 Rosenthal
R 25	see R 4	
R 26	see R 23	
R 27	see R 24	
R 28	see R 4	
R 29	see R 23	
R 30	see R 14	
R 31	see R 14	
R 32	see R 14	
R 33	see R 14	
R 34	Variable layer resistor	500 Ohm lin. ±20% Nr. 90 Ruwido
R 35	Layer resistor	100 Ohm; 0,25 W; 5% SWD 0,25 Kl 2 Rosenthal
R 36	see R 19	
R 37	Layer resistor	470 Ohm; 0,25 5% SWD 0,25 Kl 2 Rosenthal
R 38	Layer resistor	2 MOhm; 0,5 5% SWD 0,5 Kl 2 Rosenthal
R 39	see R 24	
R 40	Layer resistor	8,2 kOhm; 0,25 5% SWD 0,25 Kl 2 Rosenthal
R 41	see R 19	
R 42	see R 19	
R 43	Variable layer resistor	500 Ohm lin. ±20% Nr. 122 Ruwido
R 44	Layer resistor	220 Ohm; 0,25 5% SWD 0,25 Kl 2 Rosenthal
R 45	see R 10	
R 46	see R 8	
R 47	see R 12	
R 48	Layer resistor	22 kOhm; 0,5 5% SWD 0,5 Kl 2 Rosenthal
R 49	Layer resistor	47 kOhm; 0,5 5% SWD 0,5 Kl 2 Rosenthal
R 49a	Layer resistor	470 Ohm ..... ∞; 0,25 W SWD 0,25 Kl 2 Rosenthal
R 50	see R 19	
R 51	Layer resistor	470 Ohm; 0,25 5% SWD 0,25 Kl 2 Rosenthal
R 52	see R 19	
R 52a	see R 2	
R 53	see R 49	
R 54	Layer resistor	820 kOhm; 0,25 5% SWD 0,25 Kl 2 Rosenthal
R 55	Layer resistor	330 kOhm; 0,25 5% SWD 0,25 Kl 2 Rosenthal
R 56	see R 14	
R 57		
R 58	see R 8	
R 59	Layer resistor	15 kOhm; 0,5 5% SWD 0,5 Kl 2 Rosenthal
R 60	Layer resistor	100 kOhm; 1 W 5% SWD 1 Kl 2 Rosenthal
R 60a	Layer resistor	1 MOhm; 0,25 5% SWD 0,25 Kl 2 Rosenthal
R 61	see R 2	
R 62	see R 12	
R 63	Layer resistor	47 Ohm; 0,25 5% SWD 0,25 Kl 2 Rosenthal

Parts list for FD 1

Code	Designation	El. values, Ordering ref., Manufacturer	
R 64	see R 63		
R 65	see R 3		
R 66	see R 2		
R 67	see R 14		
R 68	see R 14		
R 69	Variable layer resistor	5 kOhm lin. ± 20%	Nr. 90 Ruwido
R 70	see R 14		
R 71	Layer resistor	470 kOhm; 0,25 5%	SWD 0,25 Kl 2 Rosenthal
R 72	Layer resistor	150 Ohm; 0,25 5%	SWD 0,25 Kl 2 Rosenthal
R 73	Layer resistor	560 Ohm; 0,25 5%	SWD 0,25 Kl 2 Rosenthal
R 74			
R 75	see R 14		
R 75a	see R 14		
R 76	see R 51		
R 77	Layer resistor	22 Ohm; 0,25 5%	SWD 0,25 Kl 2 Rosenthal
R 78	see R 43		
R 79	Layer resistor	2,2 kOhm; 0,25 5%	SWD 0,25 Kl 2 Rosenthal
R 80	Layer resistor	2,7 kOhm; 0,25 5%	SWD 0,25 Kl 2 Rosenthal
R 81	Wire-wound resistor	330 Ohm; 0,5 ± 10%	SWD 0,5 Kl 2 Rosenthal
R 82	see R 71		
R 83	see R 10		
R 84	Layer resistor	68 Ohm; 0,25 5%	SWD 0,25 Kl 2 Rosenthal
R 85	see R 10		
R 86	Layer resistor	1 kOhm; 0,25 5%	SWD 0,25 Kl 2 Rosenthal
R 87	see R 51		
R 88	see R 10		
R 89	see R 63		
R 90	see R 51		
R 91	see R 14		
R 92	see R 5		
R 93	see R 86		
R 94	see R 2		
R 95	Layer resistor	220 kOhm; 0,5 5% SWD 0,5 Kl 2 Rosenthal	
R 96	see R 49		
R 97	see R 5		
R 98	see R 86		
R 99	see R 8		
R 100	Layer resistor	4,7 kOhm; 1 W 5% SWD 1 Kl 2 Rosenthal	
R 100a	see R 10		
R 101	Layer resistor	3 MOhm; 0,5 W 5% SWD 0,5 Kl 2 Rosenthal	
R 101a	Layer resistor	4,7 kOhm; 0,25 W 5% SWD 0,25 Kl 2 Rosenthal	
R 102	see R 71		
R 103	see R 49		
R 104	see R 71		
S 1	Selector switch	A 1 "n" as to drawing	FD 1-Sch 1 Mayr
S 2	Rotary toggle switch	2-pole/off	Pessler
S 3	Selector switch	3×3	E 633 Mayr
S 4	Push button	2-pole reversible	1353 silver contact Gruner
S 5	see S 4		
S 6	see S 4		
Si 1	Fuse	1,5 Amp. medium sensitive 5×20	1,5 A DIN 41 571
Si 2	see Si 1		
Sp 1	Coil	7,7 mH; 100 kHz	FD 1 Bv-01 Schomandl
Sp 2	Coil	160 mH; 100 kHz	FD 1 Bv-02 Schomandl
Sp 3	Transformer	6,5 mH; 100 kHz	FD 1 Bv-03 Schomandl
Sp 4	Filter coil	1,65 mH; 200 kHz	FD 1 Bv-04 Schomandl

Parts list for FD 1

Code	Designation	El. values, Ordering ref., Manufacturer	
Sp 5	Coil	65 mH; 20 kHz	FD 1 Bv-05 Schomandl
Sp 6	Filter coil	130 μH; 1 MHz	FD 1 Bv-06 Schomandl
Sp 7	see Sp 6		
Sp 8	Filter coil	18 μH; 5 MHz	FD 1 Bv-07 Schomandl
Sp 9	Filter coil	18 μH; 5 MHz	FD 1 Bv-08 Schomandl
Sp 10	Filter coil	18 μH; 5 MHz	FD 1 Bv-09 Schomandl
Sp 11	Filter coil	18 μH; 5 MHz	FD 1 Bv-10 Schomandl
Sp 12	Coil	2 μH; 5 MHz	FD 1 Bv-11 Schomandl
Sp 13	Transformer	0,9 μH; 5 MHz	FD 1 Bv-12 Schomandl
Sp 14	Filter coil	2,2 μH; 5 MHz	FD 1 Bv-13 Schomandl
Sp 15	see Sp 14		
Sp 16	Filter coil	3,5—4 mH; 310 kHz	FD 1 Bv-14 Schomandl
Sp 17	Filter coil	3,5—4 mH; 310 kHz	FD 1 Bv-15 Schomandl
Sp 18	see Sp 17		
Sp 19	Filter coil	3,5—4 mH; 310 kHz	FD 1 Bv-16a Schomandl
Sp 20	Coil	150 μH; 300 kHz	FD 1 Bv-17 Schomandl
Sp 21	Coil	1,5 μH; 300 kHz	FD 1 Bv-18 Schomandl
Sp 22	Coil	2 μH; 2 MHz	FD 1 Bv-19 Schomandl
Sp 23	Filter coil	30 MHz	FD 1 Bv-20 Schomandl
Sp 24		45 MHz	
Sp 25		70 MHz	
Sp 26	Filter coil	30 MHz	FD 1 Bv-21 Schomandl
Sp 27		45 MHz	
Sp 28		70 MHz	
Sp 29	Coil	35 MHz	FD 1 Bv-22 Schomandl
Sp 30		50 MHz	
Sp 31		75 MHz	
Tr 1	Power transformer	pr.: 0—110—117—127—150—220—235 V sec.: 300 V/0,14 A; 6,3 V/6 A; 0,6, 3—20 V/0,5 A	Bv FD 1-Tr 1a Schumacher
V 1	Stabiliser	150 C 2 (0 A 2)	VALVO
V 2	Tube	EF 80 (6 BX 6)	
V 3	Tube	EF 80 (6 BX 6)	
V 4	Tube	E 80 CC (6085)	VALVO
V 5	Tube	EF 80 (6 BX 6)	
V 6	Tube	EF 80 (6 BX 6)	
V 7	Tube	EF 80 (6 BX 6)	
V 8	Tube	EF 80 (6 BX 6)	
V 9	Tube	EF 80 (6 BX 6)	
V 10	Tube	EF 80 (6 BX 6)	
V 11	Tube	ECH 81 (6 AJ 8)	
V 12	Tube	EF 80 (6 BX 6)	
V 13	Tube	EF 80 (6 BX 6)	
V 14	Tube	EAA 91 (6 AL 5)	Telefunken
V 15	Tube	ECH 81 (6 AJ 8)	
V 16	Tube	EF 80 (6 BX 6)	
V 17	Tube	EF 80 (6 BX 6)	
V 18	Magic eye (cathode ray tuning indicator)	EM 85	Lorenz
V 19	Tube	EF 80 (6 BX 6)	
V 20	Tube	EF 80 (6 BX 6)	

Part II

Converter Unit FDM 1

A. Installation and operating instructions

The Converter Unit type FDM 1 is a very useful accessory to the Service Frequency Meter type FD 1. It enables the Model FD 1 to be used also as an active frequency generator in the additional range 1 kc/s to 30 Mc/s. Furthermore, for passive frequency measurements in this range, the input sensitivity is highly increased, (required voltage for measurements below 30 Mc/s: without FDM 1 approx. 2 V; with FDM 1 only about 5 mV or less).

Due to its simple design, the type FDM 1 could be so dimensioned that it can easily be screwed to the bottom of the type FD 1 without any further changes. It makes the FD 1 only by 6 cm higher and by 3 kg heavier.

The FDM 1 is mounted to the bottom of the FD 1 in the following manner:

Unscrew the four screws holding the four rubber supports of the FD 1. Then unscrew the four fixing screws holding the base plate of the FDM 1 and remove the base plate. Now, four hexagonal bolts are visible in the four corners of the FDM 1. On top of the FDM 1, unscrew the four nuts from these hexagonal bolts, then fasten FDM 1 to FD 1 by screwing the four hexagonal bolts into the holes in the base plate of the FD 1. Replace base plate of FDM 1, attaching at the same time the four rubber supports of the FD 1 under the base plate of the FDM 1, and fasten both by means of the four screws obtained from the base plate of the FD 1. 4 nuts and 4 screws are left over. The power cable installed in the FDM 1 is plugged into the power input of the FD 1. Power is supplied to both instruments via the FDM 1.

For measurements by means of the FDM 1, the HF cable of the FDM 1 is connected to the input "> 30 Mc/s" of the FD 1. The input "< 30 Mc/s" of the FD 1 is not needed now.

Before conducting measurements where the FDM 1 is used, its frequency (60 Mc/s) should be checked and reset. For this purpose, the Model FD 1 should be tuned to exactly 60 Mc/s. (Note that the zero point of the fine tuning dial should be checked first by means of the test key S 4). Then adjust the 60 Mc/s frequency of the FDM 1 to zero beat by means of the regulator "60 Mc/s RESET" of the Converter Unit FDM 1, (check with headphones or by magic eye).

In order to measure frequencies below 30 Mc/s, the unknown frequency should be fed into the input designated „INPUT—0 to 30 Mc/s." It is measured in the range 60 to 90 Mc/s, and the 60 Mc/s frequency of the FDM 1 is subtracted from the indicated value. The measuring process itself is the same as described on page 12.

In order to produce frequencies below 30 Mc/s, add 60 Mc/s to the value of the desired frequency and set the dials of the Frequency Meter FD 1 to indicate the resulting value, as described on page 13. The desired frequency can then be obtained at the socket designated "OUTPUT—0 to 30 Mc/s."

The only servicing required by the Converter Unit type FDM 1 is to correct its fixed frequency of 60 Mc/s by comparing it with a 60 Mc/s standard obtained from the Service Frequency Meter type FD 1.

B. Mode of operation of the FDM 1

The Converter Unit type FDM 1 contains a crystal-stabilised oscillator producing a frequency of 60 Mc/s. In the case of passive frequency measurements below 30 Mc/s, this 60 Mc/s frequency is added to the unknown frequency (< 30 Mc/s), so that the latter is converted into the range 60 to 90 Mc/s and can be measured by means of the Service Frequency Meter type FD 1. From the value read on the dials of the FD 1, 60 Mc/s are then subtracted and the resulting value is the measured frequency.

The same is done when producing active frequencies below 30 Mc/s, only the other way about. The frequency value 60 Mc/s is added to the value of the desired frequency and the result located between 60 and 90 Mc/s is tuned on the dials of the FD 1. This frequency put out by the FD 1 is automatically converted down by 60 Mc/s in the Converter FDM 1, so that the desired frequency can be obtained at the output socket of the FDM 1.

The process of a measurement below 30 Mc/s shall now be explained in detail by means of the block diagram (Fig. 37) and the a-c voltage diagram (Fig. 38). The unknown frequency is applied to socket Bu 1 (INPUT — 0 to 30 Mc/s) with a voltage of about 5 mV. Tube V 1 is a wide band amplifier and conducts the amplified signal via C 5 and Sp 4 to the ring modulator (Gr 1 through Gr 4). The 60 Mc/s frequency produced by the oscillator V 3 is fed into the other branch of the ring modulator via Sp 3. The frequency of this oscillator can be checked against the 100 kc/s standard of the FD 1 and readjusted by means of the regulator C 15, which is accessible on the front panel and designated "60 Mc/s RESET." The sum out of the unknown frequency and the 60 Mc/s is of course a frequency located between 60 Mc/s and 90 Mc/s. The filter Sp 4, Sp 5, has a passband of 60 Mc/s to 90 Mc/s and it conducts the sum frequency to the input of the FD 1. The tuning circuit Sp 5, C 21, is closed via the feed-in cable (St 1, Bu 3, and R 84). R 84 is the input resistor of the FD 1. The sum frequency (f_x + 60 Mc/s) is now measured in the range 60 to 90 Mc/s of the Frequency Meter FD 1. From the value read on the dials, 60 Mc/s are subtracted, and the result is the measured frequency f_x.

In the following, the production of a desired frequency below 30 Mc/s shall be described.

Add 60 Mc/s to the value of the desired frequency and tune the FD 1 to the resulting value. The output voltage of the FD 1 is coupled to the wide-band transformer Sp 5, Sp 4, (60 to 90 Mc/s), via a connector Bu 3, St 1, and is applied to the ring modulator (Gr 1 to Gr 4) by way of the secondary. In the other branch of the ring modulator, there are the 60 Mc/s from the oscillator. The difference frequency between output frequency of the FD 1 and the 60 Mc/s frequency is led from Sp 4 via a low-pass filter (0 to 30 Mc/s) consisting of wiring capacity, D 2, and tube inherent capacity, to the wideband amplifier V 2. The amplified difference frequency is obtained at the plate via C 11 and conducted to socket Bu 2. At the output, a no-load voltage of 30 mV to 200 mV is available.

Comparison of the 60 Mc/s frequency with the frequency standard from the FD 1:

The 60 Mc/s crystal frequency is selected from the harmonic spectrum of a crystal-controlled oscillator oscillating at 60 Mc/s (tube V 3'). The 20 Mc/s crystal oscillates in parallel resonance as a frequency determining factor and is excited by means of an ECO oscillator. A filter circuit tuned to 60 Mc/s is inserted in the plate circuit (Sp 1, C 12), which selects the third harmonic. The second triode circuit (V 3") amplifies the voltage of the 60 Mc/s. The frequency of the crystal-controlled oscillator can be readjusted by means of the variable capacitor C 15 ("60 Mc/s RESET").

The 60 Mc/s frequency is purified in the filter circuit Sp 3, C 19, and obtained at tappings of low resistance from Sp 3 and conducted to the ring modulator. Through the ring modulator, the 60 Mc/s frequency is conducted to the wide-band amplifier Sp 4, Sp 5, and from there via the plug St 1 directly to the input of the FD 1. For checking the accuracy of the frequency, the FD 1 is set to exactly 60 Mc/s and the beat audible in the headphones is tuned to zero beat by means of the regulator "60 Mc/s RESET" accessible on the panel of the FDM 1.

The a-c voltage diagram (Fig. 38) shows a number of voltage values. These are only approximate values which may be used as a guide in circuit testing, but which may differ in different units. They should be measured by an appropriate low-C tube voltmeter.

The d-c voltage diagram (Fig. 39) includes the diagram of the power supply. The crystal oscillator V 3 is supplied with a stabilised plate voltage (V 4). The adjustment of the power supply to a different mains voltage is done by adjusting a contact spring to a different terminal. The d-c voltage values shown are also only approximate values.

In order to spare a second power cable, the power is supplied to the FD 1 via the FDM 1.

Fig. 40 shows a wiring diagram of the unit enabling circuit elements to be found easily.

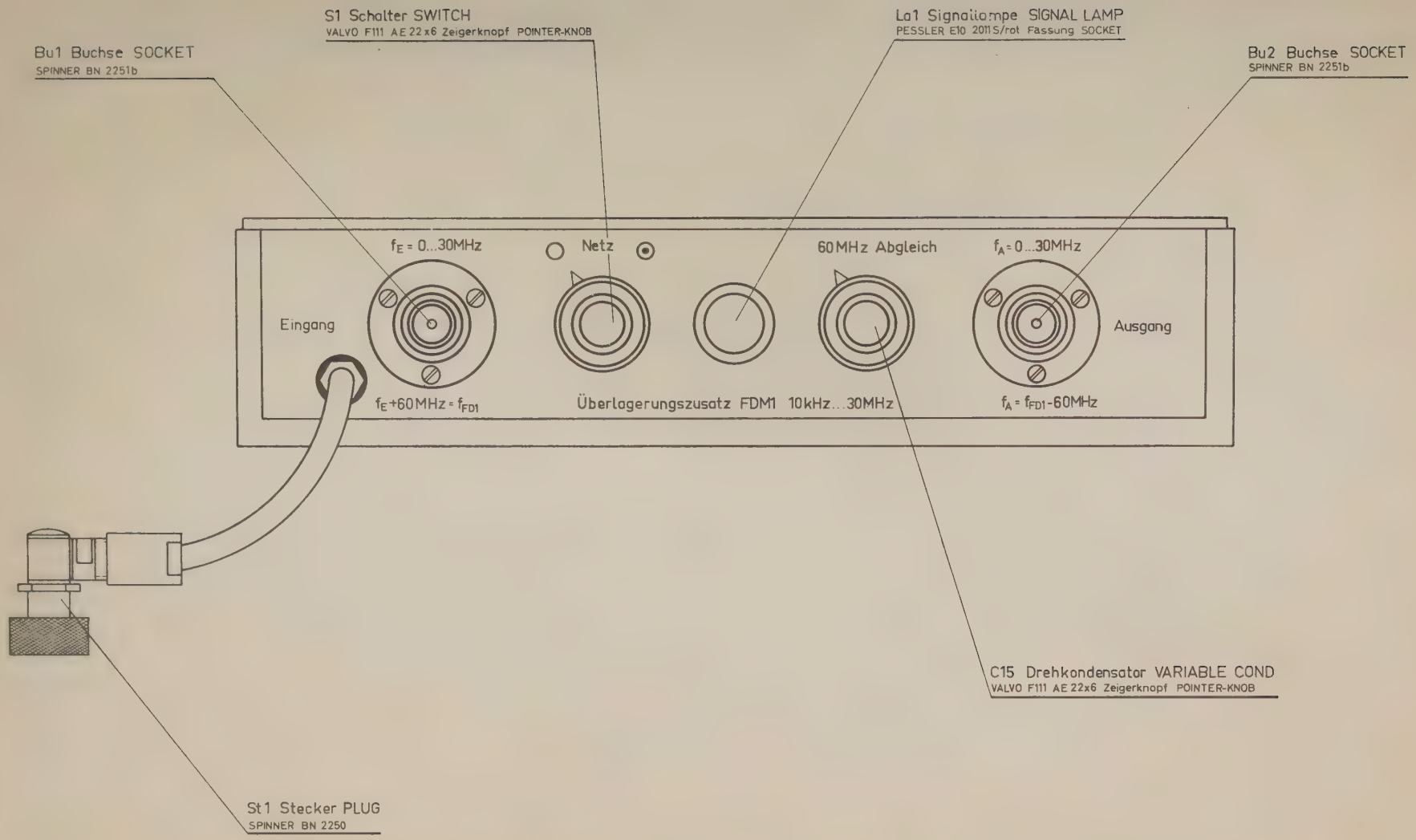


Bild 36 Überlagerungszusatz FDM1 (Frontplattenansicht)

FIG. 36 MIXER UNIT, TO FD1 TYPE FDM1 (VIEW OF FRONTPANEL)

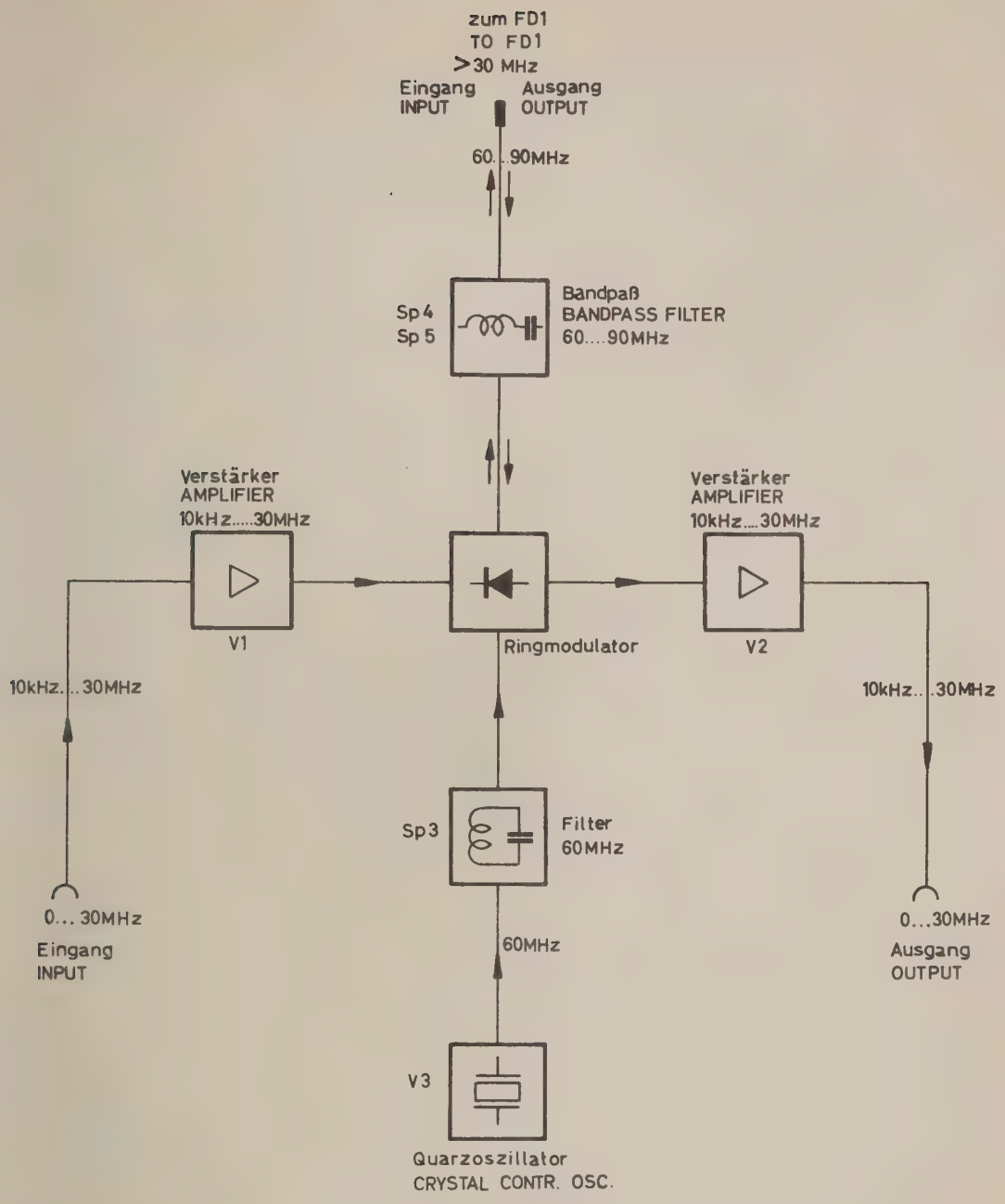


Bild 37 Überlagerungszusatz FDM1 (Blockschaltbild)
FIG. 37 MIXER UNIT TO FD1 TYPE FDM1 (BLOCK DIAGRAM)

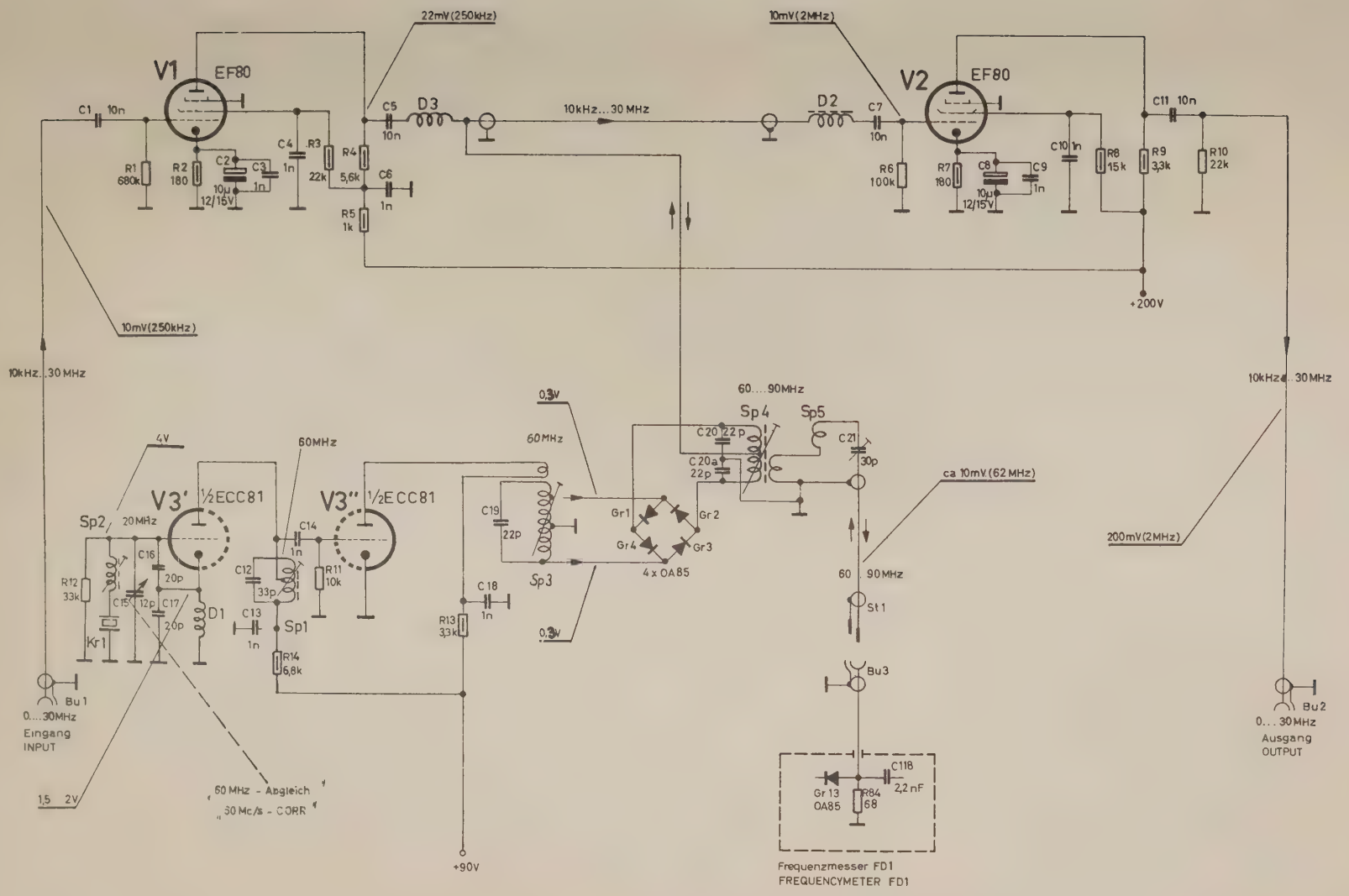


Bild 38 Überlagerungszusatz FDM1 (Wechselspannungen)
FIG. 38 MIXER UNIT TO FD1 TYPE FDM1 (A.C. VOLTAGES)

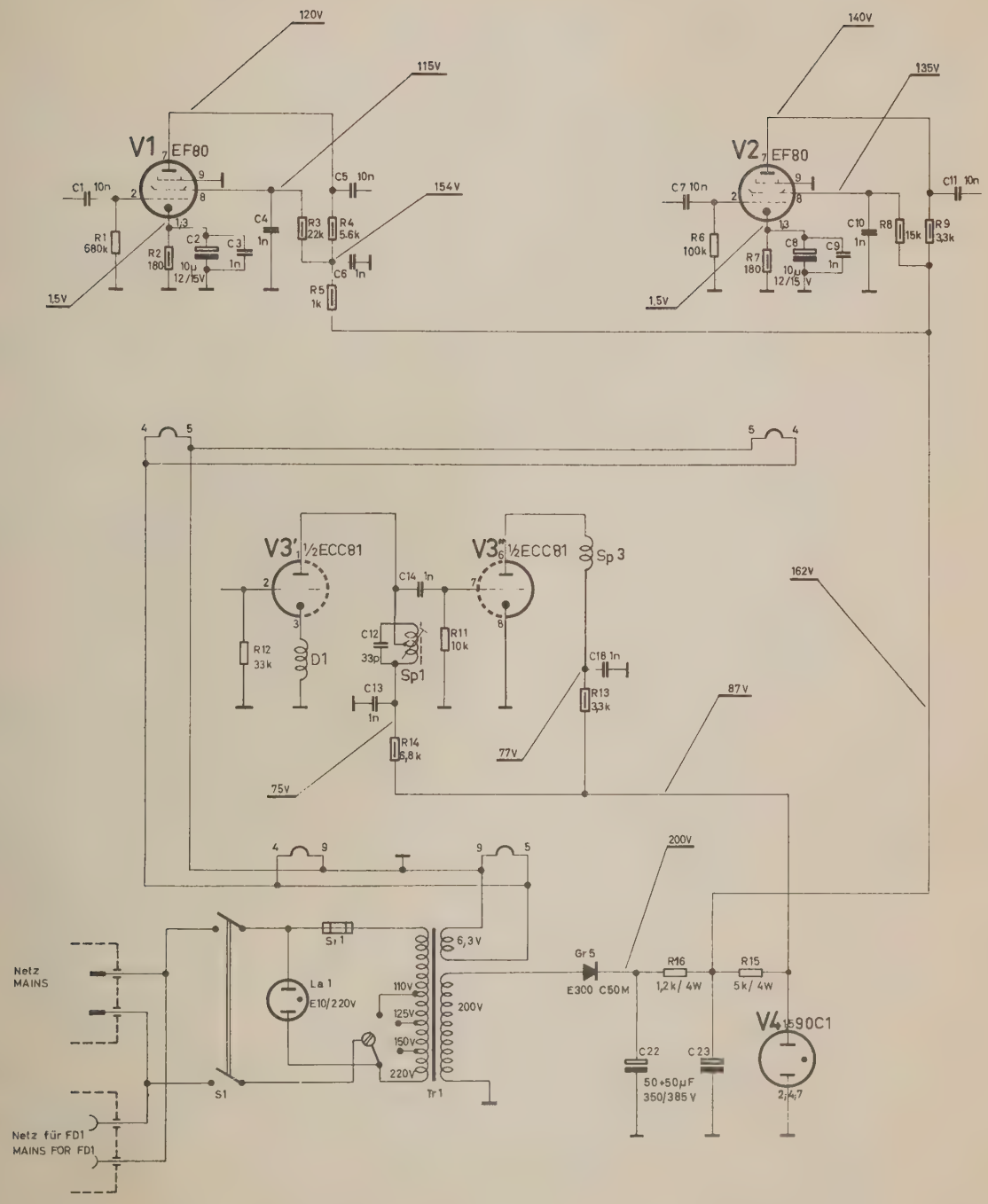


Bild 39 Überlagerungszusatz FDM1 mit Netzteil (Gleichspannungen)
FIG. 39 MIXER UNIT TO FD1, TYPE FDM1 WITH MAINS UNIT (D.C. VOLTAGES)

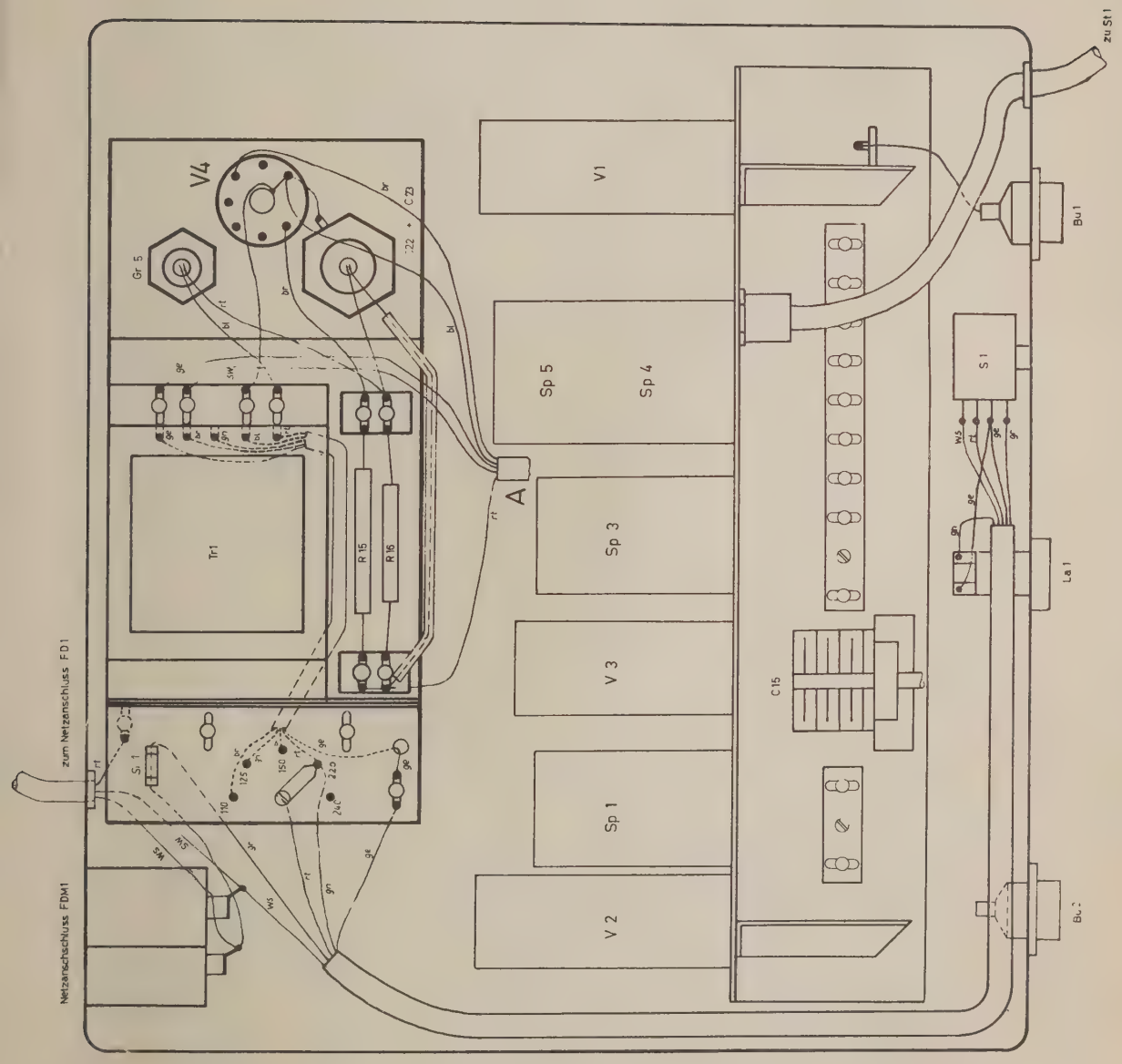


Bild 40 a Überlagerungszusatz FDM 1 mit Netzteil (Verdrahtungsplan)

Fig. 40 a MIXER UNIT TO FD1 TYPE FDM1 (WIRING DIAGRAM)

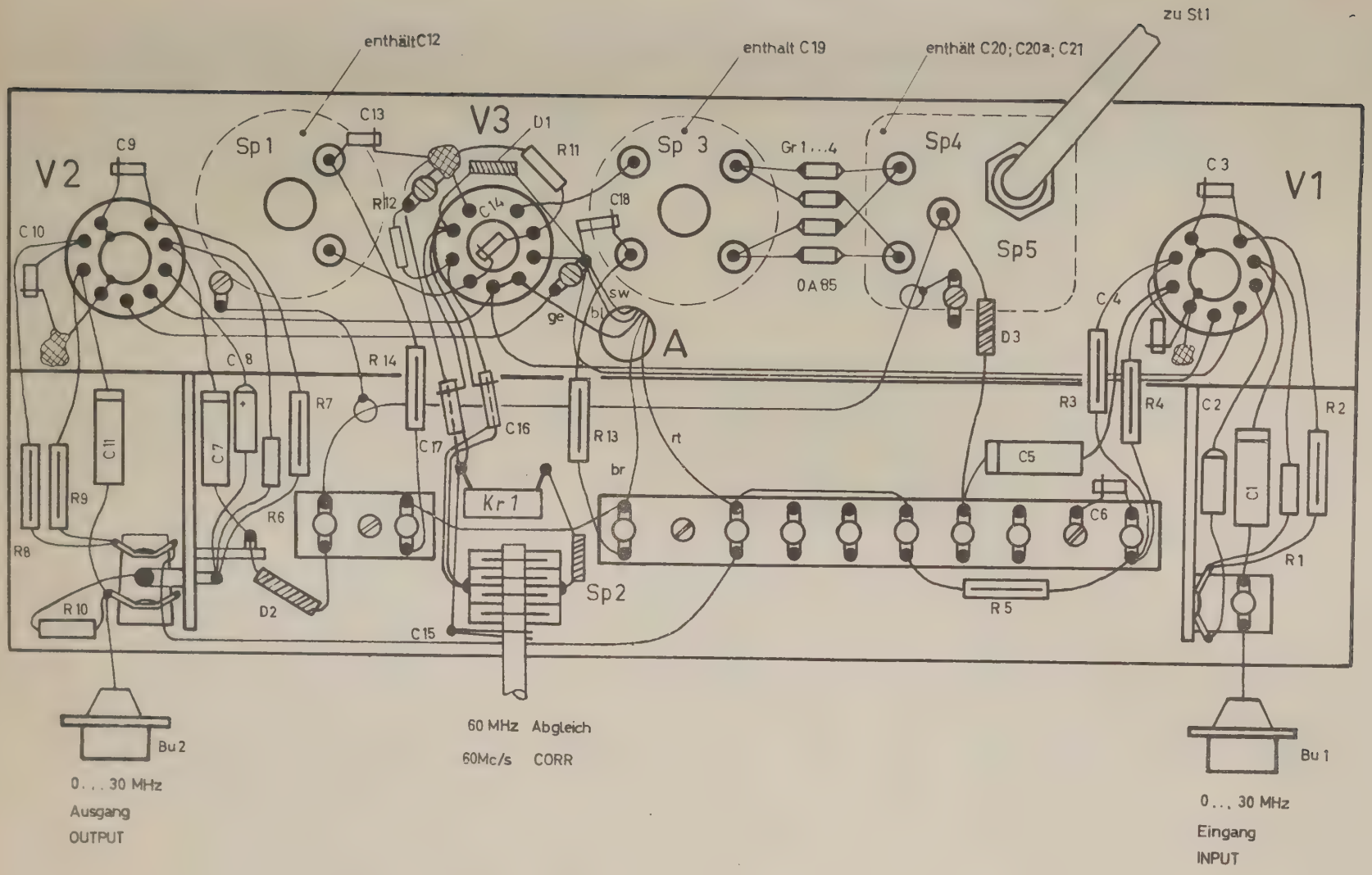


Bild 40b Überlagerungszusatz FDM1 (Verdrahtungsplan)

FIG. 40b MIXER UNIT TO FD1 TYPE FDM1 (WIRING DIAGRAM)

C.

Parts list for FDM 1

Code	Designation	El. values, Ordering ref.,	Manufacturer
C 1	Polysterene capacitor	10000 pF/20/250 B 3101	Siemens
C 2	Electrolytic capacitor	10 µF 12/15 V B 4117	Siemens
C 3	Disc capacitor	1000 pF/+ 50 —20% Sa K 2500/500 V	VALVO
C 4	see C 3		
C 5	see C 1		
C 6	see C 3		
C 7	see C 5		
C 8	see C 2		
C 9	see C 3		
C 10	see C 3		
C 11	see C 5		
C 12	Air dielectric trimmer	3—30 pF 7864/01	VALVO
C 13	see C 3		
C 14	see C 3		
C 15	Variable capacitor	10 pF 82077/10 E	VALVO
C 16	Tubular capacitor	Rk 20 pF/+0,5 pF/500 V Rd 3×12/D 20	Stettner
C 17	see C 16		
C 18	see C 3		
C 19	see C 12		
C 20	Rohrkondensator	Rk 20 pF/ ± 0,5 pF/500 V 3×16 D 20	Stettner
C 20a	see C 20		
C 21	see C 12		
C 22	Electrolytic capacitor	50+50 µF/350 V/385 V	Siemens
C 23		50+50/350/B 4313	
D 1	Choke	240 turns 0,06 CuL on ceramic former 3×20 mm with Ferroxcube stud core 1,9×23 mm (VK 20504)	FDM 1-Bv: 05 Schomandl
D 2	Choke	0,15 CuL on choke former 3×20 mm p Kerafarx one layer of turns	FDM 1-Bv: 06 Schomandl
D 3	Choke	0,15 CuL on choke former 3×20 mm p Kerafarx one layer of turns	FDM 1-Bv: 06 Schomandl
Gr 1	Crystal diode	4×OA 73	VALVO
Gr 2			
Gr 3			
Gr 4			
Gr 5	Rectifier	250 V, 50 mA E 250, C 50 M	AEG
Kr 1	Quartz crystal	20 MHz	Reuter
La 1	Glowlamp	220 V E 10	Osram
R 1	Layer resistor	SWD 680 kOhm/± 5%/0,25 W Kl 2	Rosenthal
R 2	Layer resistor	SWD 180 Ohm/± 5%/0,5 W Kl 2	Rosenthal
R 3	Layer resistor	SWD 22 kOhm/± 5%/0,5 W Kl 2	Rosenthal
R 4	Layer resistor	SWD 5,6 kOhm/± 5%/0,5 W Kl 2	Rosenthal
R 5	Layer resistor	SWD 1 kOhm/± 5%/0,5 W Kl 2	Rosenthal
R 6	Layer resistor	SWD 100 kOhm/± 5%/0,25 W Kl 2	Rosenthal
R 7	see R 2		
R 8	Layer resistor	SWD 15 kOhm/± 5%/0,5 W Kl 2	Rosenthal
R 9	Layer resistor	SWD 3,3 kOhm/± 5%/0,5 W Kl 2	Rosenthal
R 10	Layer resistor	SWD 22 kOhm/± 5%/0,25 W Kl 2	Rosenthal
R 11	Layer resistor	SWD 10 kOhm/± 5%/0,25 W Kl 2	Rosenthal
R 12	Layer resistor	SWD 33 kOhm/± 5%/0,25 W Kl 2	Rosenthal
R 13	Layer resistor	SWD 3,3 kOhm/±5%/0,5 W Kl 2	Rosenthal
R 14	Layer resistor	SWD 6,8 kOhm/±5%/0,5 W Kl 2	Rosenthal
R 15	Wire-wound resistor	GWD 4/5 kOhm	Rosenthal
R 16	Wire-wound resistor	GWD 4/1,2 kOhm	Rosenthal

Parts list for FDM 1

Code	Designation	El. values, Ordering ref., Manufacturer	
S 1	Rotary toggle switch	2-pole/off	Pessler
Si 1	Fuse	0,5 A medium sensitive 5×20 0,5 A DIN 41571	Wickmann
Sp 1	Filter coil	threaded former 5 turns 1 Cu silver plated; coil length: 25 mm; coil diameter: 9 mm; center tap	FDM 1 - Bv.: 01 Schomandl
Sp 2	Coil	50 turns 0,3 CuL on ceramic former 3×20 mm with Ferroxcube stud core 19×23 mm (VK 20504)	FDM 1 - Bv: 02 Schomandl
Sp 3	Filter coil	threaded former 7 turns 1 Cu silver plated; coil length: 26 mm; coil diameter 9 mm; taps on turns: 1, 2 and 3, 1 coupling turn	FDM 1 - Bv: 03 Schomandl
Sp 4	Filter coil	threaded former 7/34 with threaded core 7/18 spec. L 1: 6 turns 1 Cu silver plated; coil length: 15 mm; center tap L 2: 2 turns 1 mm insul.	FDM 1 - Bv: 04 Schomandl
Sp 5	Filter coil	air coil 4,5 turns 1 Cu silver plated coil length: 12 mm; coil diameter: 9 mm	FDM 1 - Bv: 04 Schomandl
Tr 1	Power transformer	pr.: 0-110-117-127-150-220-235 V sec.: 200 V; 40 mA; 6,3 V; 1 A	Bv. FDM 1-Tr1 Schumacher
V 1	Tube	EF 80 (6 BX 6)	
V 2	Tube	EF 80 (6 BX 6)	
V 3	Tube	ECC 81 (12 AT 7)	
V 4	Stabiliser	90 C 1	VALVO

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Nomenclature

of terms used in the illustrations, Figs. 1 to 6.

Fig. 1:

Oszillatorfrequenz	Oscillator frequency
Harmonische	Harmonic(s)

Fig. 2:

Hauptoszillator	Main oscillator
Normalfrequenzspektrum	Standard frequency spectrum
Filterkurve des mitlaufenden Filters (Sp 23 . . . 28)	Attenuation characteristic of the ganged filter (Sp 23 to Sp 28)
Ausgesiebte Normalfrequenz 25 MHz_Q	Selected standard frequency 25 Mc/s_Q
1 MHz Normalfrequenzspektrum	1 Mc/s standard frequency spectrum
„MHz"-Skala (Hauptoszillator)	"Mc/s" dial (main oscillator)
Hauptoszillatorfrequenz (30 MHz)	Main oscillator frequency (30 Mc/s)
Frequenzbereich 30—90 MHz	Frequency range 30 to 90 Mc/s

Fig. 3:

Oszillatorfrequenz um einen beliebigen „MHz"-Punkt	Oscillator frequency in the vicinity of any "Mc/s" point
Abhängigkeit bei ausgeschalteter Regelung (Schalterstellung „Suchen")	Response when synchronising system is switched off (Switch position: "SEARCH")
Abhängigkeit bei eingeschalteter Regelung (Schalterstellung „Messen")	Response when synchronising system is switched on (Switch position: "MEASURE")
Skaleneichung um einen beliebigen „MHz"-Punkt	Dial calibration in the vicinity of any "Mc/s" point
Instrument links neben der „MHz"-Skala	Meter to the left of the "Mc/s" dial

Fig. 5a:

Ausgesiebtes Seitenband	Selected sideband
Oszillatorfrequenz	Oscillator frequency

Fig. 5b:

Filterkurve der 5 MHz-Filter	Attenuation characteristic of the 5 Mc/s filters
Seitenbänder	Sidebands

Resistances

¼-Watt Resistance
½-Watt Resistance
1-Watt Resistance
2-Watt Resistance

Colour code

bl = blue
rt = red
ge = yellow
gn = green
sw = black
ws = white

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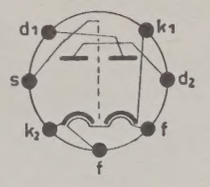

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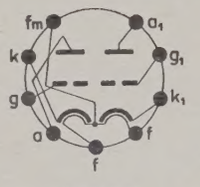

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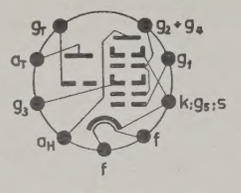

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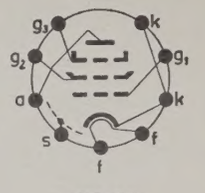

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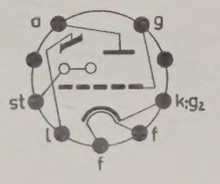

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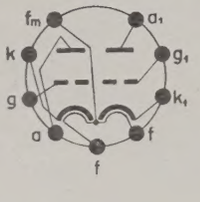

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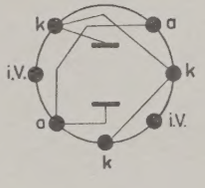

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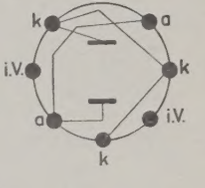

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